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FEATURING THIS MONTH . . .

Food Research in the Netherlands, 1957

Clarence Sterling *
University of California, Davis, California

IN LARGE PART, Dutch agriculture is commerce-minded; it is directed toward the export market. Of a total pork production of 292 million kilograms in 1954, over 100 million were exported; of 163 million kg. of cheese produced in that year, 97 million kg. were exported; of 5,863 million kg. of milk, almost two thirds were exported. A tremendous acreage of glass houses in the southwest part of South Holland concentrates on specialty truck crops, timed for the seller's market: tomatoes in February, cucumbers as late as November and as early as March, grapes for November harvest, and so on.

There is a strong heritage of the mercantile tradition still extant in the Netherlands. It exists not only in commerce but also in industry; it is to be found among many a large and small businessman alike. Agriculture and the agricultural-processing industries also show this heritage. The speculative philosophy of the trader (to buy cheap and sell dear) is well known, of course, in the United States. When this viewpoint is applied unmodified to food processing, the results are often not too happy. Nevertheless, particularly with many small operators, this is an important attitude in the Dutch food processing industry and must be considered in an evaluation of the food research picture in the Netherlands.

Another important background fact is that general food technology as such is not being taught in the Netherlands. The closest approach is in the agricultural engineering ("technology") curriculum being given by Prof. H. A. Leniger at the Agricultural University in Wageningen. This program is set up as follows: in the first year, there are general courses, including basic sciences and mathematics. The program of the next three years emphasizes chemistry, physics, microbiology, and unit operations in technology. (The student also takes courses in mathematics, botany, nutrition, mechanical engineering, economics, etc.). However, this curriculum has just started this year and has not been able to provide graduates either for research or for industrial work.

Fruit and vegetable research. Although there are no governmental laboratories doing research in food processing problems, two large quasi-governmental organizations dominate food research in the Netherlands. One of these, and the only one whose commodity activity is in the area of processed fruits and vegetables, is the Institute for Storage and Processing of Horticultural Products (IBVT) at Wageningen. Over 100 people are employed here, 14 of whom have an academic degree. To various extents, the members of the staff will engage in extension activities with farmers, auction groups, or processors and carry on research.

A conspicuous feature of the work of the laboratory is the performance of quality control determinations for private industry. Such work is paid for by the particular company which wishes a continuing evaluation of its products. However, the control is not statistical production control, and the testing method is generally in terms of some organoleptic evaluations by a panel selected from within the laboratory. Other companies will pay for research either in product development (dehydrated soup) or in product stabilization (conditions of fruit storage; fruit disintegration in jams). The payments from private industry and from a few army contracts account for about 20% of the total budget of the institute, the remainder being provided by the government.

The physical plant of the institute was completed in 1952. The large pilot laboratory, about 6500 square feet in area, contains such items of equipment as jam concentrators, juice presses, retorts (Figure 1), a blancher, blast freezer, juice pasteurizer, juice concentrator, and still. A large experimental dehydrator (Figure 2) and two small insulation-testing buildings

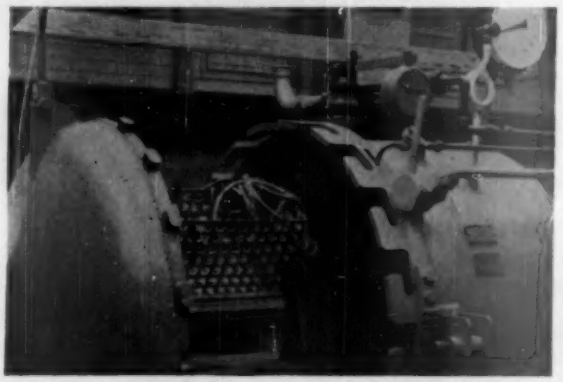


Figure 1. Experimental retort of IBVT at Wageningen. The wires are thermocouple leads which are placed in cans on the rotating racks.

dominate the pilot plant by their size. Unfortunately, the equipment is not readily mobile, so that working space tends to be somewhat restricted in some areas. Surrounding the pilot plant are workshops, storage areas, incubator rooms, and refrigerated cold storage and freezing rooms—supplied from a large central compression station (Figure 3).

In the biochemical group, work is being done on physiological changes which occur during apple ripening. Ir. J. J. Doesburg has found no evidence of pectin hydrolysis during apple ripening and little change in

(Continued on page 6)

* The author wishes to take this opportunity to thank the directors and staffs of the various Dutch research organizations which he has visited for their friendliness, helpfulness, and unfailing courtesy. The experience has been most enjoyable. It is a pleasure to acknowledge the financial support of the U. S. Educational Foundation in the Netherlands.

ANNOUNCING

THE 1957 GLYCERINE RESEARCH AWARDS

FIRST AWARD $1,000
SECOND AWARD 300
THIRD AWARD 200

These annual awards were established in 1952 to recognize research leading to new and improved applications of glycerine and glycerine derivatives. Award winning work may deal with the chemical, physical or physiological properties of these materials; with actual or projected uses; or with scientific principles likely to stimulate future applications. Originality in extending the usefulness of glycerine into new fields will receive special consideration.

BASIS OF ENTRY

These awards are open to any individual in the United States or Canada engaged in research, either in industry or with government or educational institutions. Entries by research teams of two or three associates are eligible. Persons connected with member companies of the Glycerine Division, Association of American Soap & Glycerine Producers, Inc., or laboratories which they employ are not eligible.

First consideration will be given to work which has come to a clear-cut point of accomplishment during the current year; but work carried on in previous years, the significance of which has been confirmed by commercial application in 1957, also will be eligible.

Entries will be judged by a committee of three persons of outstanding reputation and scientific background, having no connection with the Association or its members.

METHOD OF NOMINATION

Nominations must be made on the official entry blank, which may be obtained by writing to: Awards Committee, Glycerine Producers' Association, 295 Madison Avenue, New York 17, N. Y.

All nominations for the 1957 awards must be received by November 1, 1957 to be eligible.

Honor Role of Glycerine Research Award Winners

1952

First	Dr. Ivan W. Brown, Jr. Duke University School of Medicine and Rev. Basile J. Luyet Institute of Biophysics, St. Louis University
Second	Dr. Raymond Reiser and Dr. Hermann Schlenk Texas Agricultural Experiment Station
Third	Research team at Southern Regional Research Laboratory headed by Dr. Reuben O. Feuge

1953

First	Dr. Erich Baer University of Toronto
Second	Dr. Lewis I. Gidez Brookhaven National Laboratory and Dr. Manfred L. Karnovsky Harvard Medical School
Third	Albert C. Nuessle Rohm & Haas and Russell F. Crawford, Jr. Sharon Hill, Pa.

1954

First	Prof. Robert K. Summerbell Northwestern University and Dr. James R. Stephens American Cyanamid Co.
Second	Two research teams: Dr. Robert W. Swick and Akira Kakao of Argonne National Laboratory and Dr. Harland G. Wood and Dr. Per Schambye of Western Reserve University
Third	Dr. Henry A. Sloviter University of Pennsylvania

1955

First	Dr. Reed A. Gray Merck & Co.
Second	Dr. Eugene P. Kennedy University of Chicago
Third	Dr. Karl H. Lauer University of Alabama

1956

First	Dr. Herbert J. Dutton U. S. Dept. of Agriculture
Second	Dr. Donald Zilversmit University of Tennessee
Third	Dr. Stanley G. Knight University of Wisconsin

(Continued from page 4)

the degree of pectin esterification throughout the growing season. Hence, he believes that softening may be due to an extraction of calcium from the cell wall pectin by organic acids in other parts of the cell via ion exchange. This work has led to investigation of the organic acid constituents of the ripening fruit as well as exploration for effective indices for determining stages of maturity. In another direction, he and Ir. G. Grevers have developed a "Hardness-meter" (Figure 4) which is being used extensively in Europe for determination of toughness in fruits and vegetables. It has a shearing head and test box somewhat like that of the Kramer "Shear-press."

The cold storage rooms are also the site of much experimental work, particularly regarding the rôle of storage atmospheres and temperatures in fruit stability and in gas evolution from the stored commodities. The visitor is impressed with the amount of time and space devoted to the problems of apple physiology, in both freshly-harvested and stored conditions. (Less space is allotted to stored grapes, carrots, and celery tubers.) This work on storage of unprocessed foods is an important function of the institute. Not only is research being carried out on the physiological aspects of cold storage but also on its engineering aspects—in particular, on the insulation of cold storage houses. Some recent work of this group under the director, Ir. T. van Hiele, has shown a possible reduction of 80% in construction costs in addition to increased efficiency by the substitution of cheaper materials and by a reversed arrangement of the usual moisture-barrier and insulation combination.

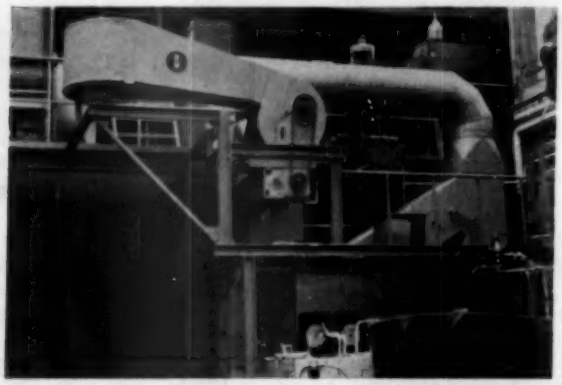


Figure 2. Upper part of IBVT dehydrator. The long tube overhead permits easier calibration of the flow rate. Moreover, humidification of the air and measurement of that humidity occurs in this section. Forking of the descending arm at the right permits the use of a shut-off baffle to deflect and contain the air of the dehydrator while the test chamber is opened for weighings or other purposes.

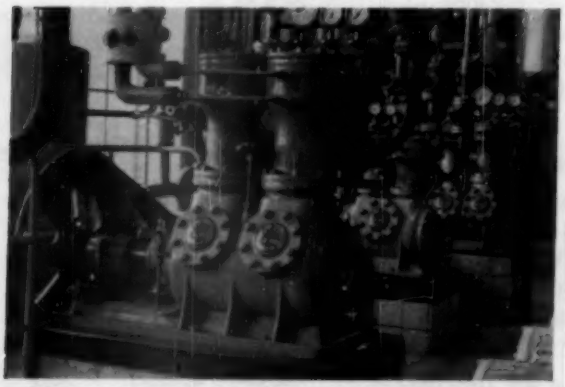


Figure 3. Some of the compressors in the engine room of the IBVT pilot plant. These service 6 cold storage rooms and 3 rooms for freezing storage.

Research problems for the Institute are chosen by the staff, subject to the amendment and approval of a governing board, which has 9 members from industry (including various growers and wholesalers as well as processors) and 10 advisory members from the Agricultural University and the government. Hence, the problems chosen tend to be those which are of immediate interest to the industry and which are susceptible of solution by experimental application of broad principles of food technology or plant physiology. Possible future research is being considered on problems of truck transportation of perishable commodities, the microbiology of sugar, bacterial flora in dehydrated footstuffs, development of mold in sulfited strawberries, and cold storage of tomatoes.

Figure 4. IBVT Hardness-meter. According to the size of the spring used, this instrument can measure the breaking strength of a pectin film or of a test-box full of tough peas. All the parts can be folded in to make a compact, box-like unit for transportation. It is sold by IBVT for 1600 guilders.

T. N. O. Pervading almost all aspects of Dutch industrial life is a virtual colossus of research organizations, the TNO (Organization for Applied Scientific Research). Institutes of this organization are investigating subjects ranging from stresses in boat parts to electron microscopy of lard to problems in breeding animals for medical research. Before considering the institute which is engaged in food research, it might be of value to describe some significant aspects of the TNO.

In 1930, the law creating TNO was passed, for the following aim: "That there be a central organization for applied scientific research, of which the task will be to ensure that this research is put to the service of the common good in the most purposeful manner possible." Although its function is research, when no other laboratory is available, a TNO institute will do occasional control analyses for a factory or even for an industry. When a factory asks for original research to be done in a certain area and pays for that research in full, it is entitled to a two-year period of secrecy on disclosure of the results and acquires any patents which may arise from the work. Often the fees charged do

(Continued on page 8)

Aluminum Foil Packaging– Advantages of High Thermal Conductivity

Report No. 9 of a Series by Reynolds Metals Company

Thermal conductivity is a property often overlooked or considered of little consequence in the selection of packaging materials. Growth of the frozen and refrigerated foods industry, however, is placing increased emphasis upon the thermal properties of the package. Frozen foods producers are interested in faster and more efficient freezing. Grocers are interested in obtaining maximum efficiency from storage cabinets – which are frequently overworked. And, of course, the ultimate consumer is interested in rapid thawing or heating. The high efficiency of aluminum foil as a conductor of heat makes it unique among flexible packaging materials.

Both freezing and thawing can be speeded by aluminum foil's high thermal conductivity – by faster removal of heat from the package in air blast, plate or immersion freezing, and by faster transfer of applied heat into the package in thawing. On the other hand, where heat is conveyed by radiation rather than by contact, the high radiant heat reflectivity of aluminum foil will retard thawing rates.

Still other benefits are to be gained in storage situations where it is important to minimize temperature fluctuations. As an illustration, the accompanying graph shows the temperatures of ice cream in pint packages of waxed fiberboard cartons with and without aluminum foil overwraps. These packages were stored in an open top refrigerated display cabinet typical of those generally found in self-service markets.

It is a well documented fact that ice cream deteriorates rapidly through softening, shrinking and coarsening of texture if the temperature rises even a few degrees above its proper storage temperature. The most severe test of the packaging material, naturally, takes place in the top layer of the storage cabinet since exposure to radiant heat and convection currents is greatest at that point. Practical experience shows that ice cream in this location does, in fact, deteriorate most rapidly.

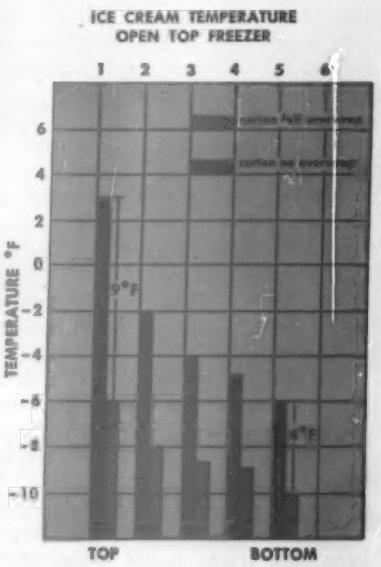
Test results shown in the graph indicate that, in this most exposed layer, the ice cream in foil wrapped cartons was held at 9°F *lower* temperature than ice cream in plain cartons on the same layer.

Even in the bottom layer, where radiation and convection are minimized, the temperature of foil wrapped ice cream was maintained at 4°F colder than ice cream in plain cartons.

Two properties of the aluminum foil wraps were responsible for maintaining these important lower temperatures. First, the great reflectivity of aluminum foil reduced the temperature rise due to radiant heat. Second, the high thermal conductivity of the aluminum permitted the gained heat to be conducted downward to the colder areas of the cabinet where it was effectively removed by the refrigeration equipment.

The absolute temperature values are not the significant point. What is significant is that the ice cream in plain cartons on the upper levels deteriorated while the foil wrapped ice cream on the same levels did not because lower temperatures were maintained.

Your local Reynolds representative will be glad to show you how aluminum foil packaging can best meet your individual problem. Or you may write direct to **Reynolds Metals Company**, General Sales Office, Louisville 1, Ky.



See "CIRCUS BOY", Reynold's new dramatic adventure series, Sundays, NBC-TV Network.

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(Continued from page 6)

not cover the costs of all the research done, but there is always a fee for the work—even if only nominal.

Operating funds for a TNO institute are derived in part from the government, in part from fees for the work performed, and in part from grants from industry groups. However, the TNO is like a corporation which can act in its own name, free from the direction of government or any industry. It does not have to consult any group in its actions. All decisions for an institute's research activities are made by a Board of Directors, which includes scientific people (mostly from the universities), people from industry, and usually a delegate or two from the appropriate governmental ministry concerned.

Within the TNO, in addition to a central administrative council, there are five autonomous councils (each embracing a number of related research institutes):

Industrial Research Council TNO, whose member institutes do research in such industries as textile, leather, rubber, bicycles, etc.,

Nutritional Research Council TNO, for research in foods and nutrition,

Agricultural Research Council TNO, doing research on forest products, soils, biocides, etc.,

Defense Research Council TNO, whose institutes work on medical, physical, and chemical problems for military operations,

Health Research Council TNO, for work in hospital problems, pharmaceutical research, etc.

Food and nutrition research. The Nutritional Research Council TNO has only one institute in its organization, the Central Institute for Food and Nutrition Research (CIVO). The headquarters of the institute are in Utrecht, a branch fisheries research department being located at IJmuiden on the North Sea and a branch cereals research department at Wageningen. Studies are being carried out in food technology as well as in human nutrition—particularly the nutrition of young children. The director, Dr. M. van Eekelen, feels that nutrition problems in the age range, 0–5 years, are especially important developmentally.

The work of the institute on nutrition of the coeliac child is an excellent illustration, Dr. van Eekelen believes, of the value of conducting research in food technology and in nutrition together. Fat diarrhoea is a particular manifestation of coeliac disease, and the excreted fat was formerly thought to come from the ingested food. However, the excreted fat was found to have a different fatty acid composition from the fats which were consumed. Moreover, fat excretion occurs even when fat-free diets are fed. Hence it became apparent that the fat was being derived from the body itself. Then it was found that wheat products in the children's diet (the children being patients at the Children's Hospital nearby) were accentuating the disturbing symptoms of the disease. (To some extent, oat and rye were also offenders. However, corn and rice were found to be acceptable cereals.) The difficulty was soon traced to the wheat protein, particularly its gliadin fraction. It was also noted that coeliacs have a higher polypeptide level in the blood than do normal children after consuming wheat proteins.

Elimination of wheat products from the diet was found to be almost immediately effective in bringing about a "cure". Although further fundamental studies in connection with these intriguing relationships immediately suggest themselves, and are being pursued, a basic solution has been satisfactorily attained—and at an eminently practical level.

Nutrition research is also carried out with animal subjects, such as rats, chickens, and pigs. The laboratory maintains colonies of animals for such work as well as for preliminary orientation toward toxicological properties of certain chemicals. The use of 1-day old suckling pigs (Figure 5) is felt to be especially helpful,

Figure 5. One-day old pig in cage at CIVO. Infra-red lamps above keep the young animals warm.

since these will approach the physiology of the human infant much closer than will young rats. Moreover, the litters are large (8–12), so that siblings are available; and the 1-day old pig will forage readily for itself in a cage (Figure 6).

In the food technology program, bacteriological emphasis has been primarily on food spoilage—in cans, in sausages, in the ingredients of chocolate, etc. Additional programs are being carried out on problems in fat hydrolysis as well as on rancidity resulting from oxidation of fats. Gas chromatography is being used in various studies, ranging from identification of flavor and color components in coffee to the characterization of the fatty acids found in the blood stream of children. Infra-red apparatus will soon be available here to increase the range and sensitivity of the analytical work. At present, much routine analysis is being performed on the vitamin and amino acid composition of foods (and sometimes feeds!). A program with meats, particularly on various problems of sausage-making, has been inaugurated within the past year.

The future for the institute looks especially bright. A new large building is being planned in the town of Zeist, near Utrecht. This will have a modern pilot plant to speed along the processing aspects of the food research program. Future work will stress research on flavors and flavor components of foods. A particularly valuable feature of this institute's outlook, the writer believes, is that it permits the young scientists

(Continued on page 10)

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Vanilla Bean Flavor by Firmenich stems from the vanilla bean. By original research, its components and desirable characteristics have been isolated, identified, and synthesized. By patient and painstaking laboratory techniques, they have been reconstructed for you in a precise and potent flavor material with all the aromatic qualities of the original. Vanilla Bean Flavor by Firmenich comes to you as an economical replacement of pure vanilla extract, of pure vanillin, or to use in combination in the manufacture of all products that you flavor with this most popular of flavors. Contains no coumarin.

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(Continued from page 8)

here to work on problems which are acceptable for doctoral theses at the universities and yet fit in with the research goal of the institute. Already a good score of such theses are to be found on the shelves of the institute's library.

Figure 6. One-day old pig, foraging in its cage. These animals can readily be taught to eat by themselves—so are not at all disturbed at being removed from the sow.

Fisheries research. In contrast with the 85-member staff in the Utrecht laboratories, only 10 people are carrying on the work of the fisheries research department of CIVO at IJmuiden. The main goal of their efforts is technological: to improve existing methods of fish processing and thereby to improve the quality of the processed product. An example may be cited from the projected work on smoking of fish. Currently a new smoking plant is under construction, with steel girders and arches, brick walls, concrete floor, smoking chambers, experimental chamber for recirculating smoke (wood being an expensive commodity in the Netherlands), overhead conveyors for the racks of fish, and cooling and washing rooms. The reasons for this elaborate arrangement are two-fold: first of all, it is obviously contemplated to carry on considerable research in smoking problems; however, a more covert secondary aim is to demonstrate better processing techniques to an industry which is still working with centuries-old methods.

It is often noted that, if the general level of operation of many small Dutch food processors may be described as primitive, that of the fish processors is almost archaic. Not only are the methods old and the operations unsanitary, but the flavor of the product is exceedingly variable, and spoilage is not at all uncommon. Despite the large quantity of processed fish exported by this country, the internal consumption is quite low, amounting to about 20 pounds per person per year. It is felt that in a country with a generally low protein consumption and yet abundant fishery resources making for cheap fish, such a discrepancy can only be due to the poor quality of the product.

It is proposed, then, to study the conditions of smoking for different products (type of wood, air speed, smoke density, temperature, etc.), to investigate the problem of mold inhibition and the inhibition of *typhus* in the popular smoked fresh-water eels, and to try out smoking-canning techniques with herring and other fish. Also being probed are the use of antibiotics with ungutted fish, production of frozen fish sticks, prevention of microbiological spoilage in marinated herring, and conditions of freezing fresh sea food products, such as oyster, shrimp, and herring. Somewhat more fundamental research concerns the physical changes which occur in frozen fish during storage (in particular, the continual increase in muscle toughness) and the enzymatic "ripening" of salt-cured spring herring.

The research group is located in the same building with a marine biological station, which carries on research in topics such as water temperatures, salt composition, and fish spawning habits. (IJmuiden is a large commercial port for fresh fish from the North Sea.) As in all Dutch laboratories, there is a precision machine and metal-working shop—with skilled machinists staffing it. The pilot plant has a blast freezer (Figure 7), cabinets for freezing storage and cold storage, and canning equipment.

Cereals research. The subgroup of CIVO which specializes in baking problems is the Department for Grain, Flour, and Bread Research (or cereals research department), with about 40 workers, at Wageningen. About 70% of its work is "free" research, *i.e.*, research not being paid for by a particular industry, and in large part embraces the determination of baking quality of native wheat and rye, particularly from small samples supplied by breeders. Since the research is mostly government-subsidized, it often goes to important problems in food science.

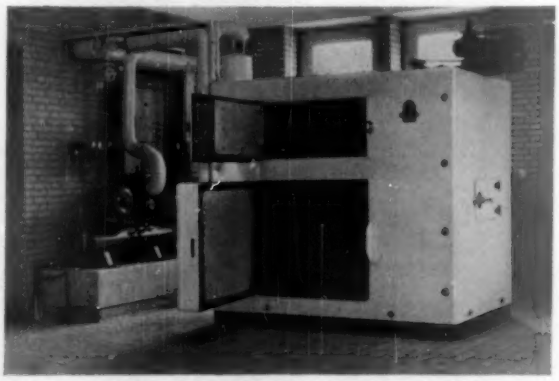

Figure 7. Blast-freezer in fisheries research department of CIVO at IJmuiden. The cleanliness of this pilot plant serves as a silent object-lesson to visitors from fish-processing enterprises.

One program of interest is essentially a study of crumb texture of bread, as it is affected by the various components of the dough. In order to evaluate the rôle of each entity of the dough, synthetic flour doughs are made, with ingredients varied at will, from which bread is baked. The dough may be wholly gluten or wholly starch or mixtures of these in varying proportions. There may be added different types of glycerides, sugars, or other compounds. After baking, the loaf is cut open and the crumb surface photographed (Figure 8). The volume (and density) of the bread are meas-

(Continued on page 12)

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(Continued from page 10)

ured and its organoleptic qualities recorded. Combined with such an approach, a study has been conducted on the rate of metabolism of different kinds of sugars by bakers' yeasts as a function of time. Thus, both paper chromatography of the sugars and the loaf volume and density determinations indicate that maltose is utilized much later than the other sugars, and that its presence has a depressing effect on loaf volume.

Another study concerns the rôle of proteins in bread-making, particularly as they affect dough properties. This approach involves an analysis of the rheological properties of pure wheat protein gels during creep. It is worthwhile to note that such rheological properties have for years been the standard baker's, as well as the

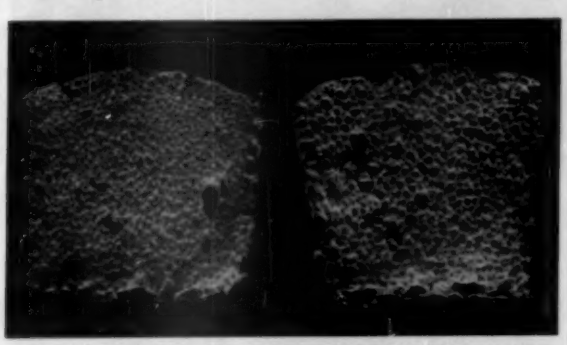

Figure 8. Interiors of loaves of bread baked from "synthetic" dough by Dr. Jongh of the cereals research department of CIVO. The doughs used for these loaves contained only starch and a small amount of glyceride.

laboratory worker's, index of the bread-making quality of a dough. The literature of bread technology is rich in fundamental and applied rheological investigations.

In the technological laboratory, which is closely connected with the experimental bakery, instrumentation for the measurement of physical properties of both dough and finished baked goods is present in abundance. The laboratory has developed its own "panimeter," which gives a continuous recording of the curves of creep and recovery of a sample of bread crumb during application and removal of a specified load in a particular manner. Many years of developmental work and testing have made its users confident that such an instrument—and the proper interpretation of its data—is a more than adequate substitute for the subjective "feel" of a loaf of bread as an index both of bread quality and of the rate of staling.

Since the final proof of a flour's quality must reside in the baked product which is derived from it, the experimental bakery (built 2 years ago) has an important place in the institute. Its operations are highly controlled, beginning with the fumigation of incoming samples, their storage at 8° C., sieving and cleaning of kernels, etc. Temperature control in the bakery room is scrupulously observed, and the operations are carefully standardized so that all dough-handling and baking conditions are exactly alike. The present bakery operations range from pilot plant scale to micro-baking techniques that can bake a loaf of bread from as few as 8 g. of flour (Figure 9). Hence, extremely small

Figure 9. "Micro-loaves" of bread and the pans in which they are baked. Extremely small samples of wheat can thus be tested for bread-making quality.

samples can be tested for their bread-making qualities. (Also on the micro scale, a method has been devised here to assay the α-amylase activity of a single kernel of wheat viscometrically.) It is expected soon that the bakery will be able to duplicate commercial baking conditions.

Technology research. At Wageningen's Agricultural University, the new Technology Laboratory of Prof. Leniger has over half a million guilders' worth of equipment for the study of general processing relationships (Figure 10). Much of the equipment has been built in the laboratory's own machine shop (Figure 11). There are various types of retorts (including an induction-heating type), presses, mills, extractors, concentrators, heat exchangers, stills, pumps, and pipes available for all sorts of unit operations studies.

Heat transfer problems are being accorded considerable attention: in plate heat exchangers, in packaged materials, in granular substances, and as related to the rheological behavior of a material. Similar fundamental studies are being made on milling technology, on low temperature evaporation, on pressure-relations of the flow of granular substances, on hydrocyclones, etc. On the biochemical side, problems with specific food materials are being investigated. One project is devoted to the manufacture of purified proteins from potatoes,

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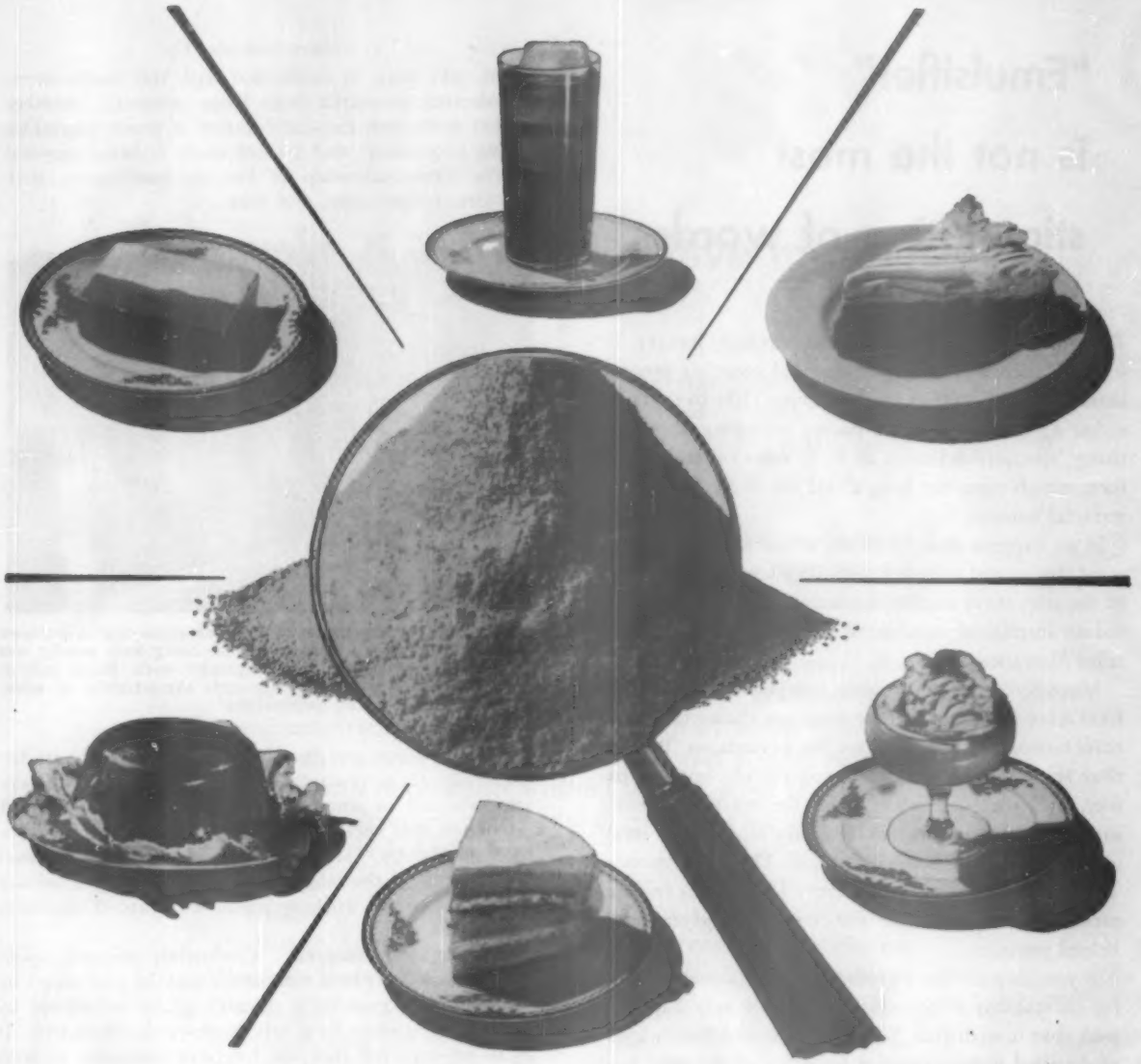
Figure 10. Continuous counter-current extractor in the Technology Laboratory of the Agricultural University. This unit, made by De Smet of Belgium, is the only one of its kind.



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(Continued from page 12)

grains, and peas, in connection with the simultaneous manufacture of starch from these products. Another project deals with the discoloration of green vegetables during processing; and a third study is being pursued on the interrelationship of enzyme inactivation with moisture, temperature, and time.

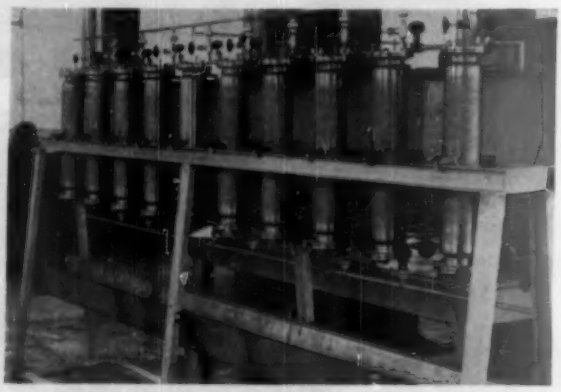

Figure 11. Construction of bank of extractors in machine shop of Technology Laboratory. Also being built nearby was a fraction separator for chromatographic work. Shops such as this, with skilled machinists, are quite characteristic of scientific laboratories in the Netherlands.

Because there can be no industrial pressure in the university, these research projects do not have to have any practical or immediate significance. However, it is obvious that such studies can hold much promise for food technology. The work is being executed in part by the staff of the laboratory and in part by graduate students who are working for their advanced engineering degree.

Private food research. Exclusively privately-sponsored research in food technology may be performed by a single factory or by a research group subsidized by several factories or by a private research laboratory. It is to be expected that the foremost functions of such research will be the control of quality—in both raw materials and processed product—and trouble-shooting. Some factories will go beyond this limited objective and engage in more exploratory research—either in the realm of methodology or in new product characterization.

Unfortunately, private research is often not published, and the research group is frequently reluctant to let be known the sort of work in which it is engaged. This attitude is particularly noticeable at the individual factory level. The writer visited such research groups in a chocolate plant and in a fat and oil factory. The research laboratories engaged in much work beyond quality control necessities (Figure 12) and usually had installed considerable pilot plant equipment to undertake research in their own and their customers' problems (Figure 13).

An example of a laboratory which is maintained by an industry is the one year old Central Institute for the Licorice Processing Industry, in Amsterdam. Here again, the primary goal of research is the evaluation of the quality of the raw materials of the licorice industry

(Continued on page 16)

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(Continued from page 14)

(licorice root, gum arabic, sugar, and glucose—starch not being used in the Dutch licorice confection) and control of the quality of the finished product. Because of the medical qualities of glycyrrhizine (hormonal effects similar to those of desoxycorticosterone and a therapeutic value in ulcer treatment), the licorice manufacturers do not share the defensive attitude of the rest of the confectionery industry. The director of the laboratory, Dr. C. Nieman, is a biochemist with a nutritional background. He hopes to initiate work soon on nutritional properties of the licorice confection and

Figure 12. Dilatometers being used for study of properties of experimental "new" fats in a factory laboratory.

Figure 13. Cooling tunnel used in a factory pilot plant to harden chocolate coatings. This installation is part of a large group of apparatus used for trouble-shooting research for customers as well as product characterization.

perhaps on the metabolism of gum arabic, which can constitute as much as 50% of the finished product.

Dairy research. The Dutch dairy industry also supports its own research organization, the Netherlands Institute for Dairy Research (NIZO) at Ede, which with a staff of 65 is the third largest food research organization in the Netherlands (Figure 14). In addition to the Laboratory of Dairying at the Agricultural University in nearby Wageningen, this laboratory does all the dairy research in the Netherlands today. (There is no governmental research in dairy technology, the former laboratory having been disbanded. The director of NIZO, Dr. J. W. Pette, was formerly a member of the government laboratory.) The laboratory and factory

Figure 14. Buildings of Netherlands Institute for Dairy Research (NIZO). At right center are the two wings of the laboratory building and in the left background is part of the institute factory.

buildings of the institute were built in 1954-1955 at a cost of 7 million guilders, much of which was raised privately through a levy on the sales of milk. Continuing maintenance is also met by an annual levy on the producers of 2 cents per 100 kg. of milk.

Some voice of the government in the research policy is effected, however, through the appointment of a representative from the Ministry of Agriculture to the Board of the Institute. This board passes on the annual research program, which constitutes about 90% of the work of the institute. The institute also tests dairy machinery and raw materials (at the expense of the manufacturers of these items) and does trouble-shooting for the member factories when needed (at no expense to the members). The reports of its research generally appear in the *Netherlands Milk and Dairy Journal*, whose editorial offices are also housed in the laboratory building.

Special additional services for the member dairies and cheese-makers are the sending of reprints of research investigations of the institute, preparing reports for them on results of testing proposed machinery and chemicals, testing new processes on a *commercial* scale in the institute factory, and preparing sterile starter cultures for yoghurt, cheese, and butter manufacture for distribution to the members. (Since this last program was started, the quality of yoghurt has improved to such an extent that its sales have risen in 5 years from 25 million to 68 million kg. per year.)

In the chemical and physical laboratories, one important research program is based on the problem of the development of an oxidized flavor (fishy taste) in cold storage butter. Last year 15 million kg. of such butter could not be sold for export and had to be disposed of at a price about 20 million guilders below cost (on the home market). One mode of attack is the investigation of the rôle of copper ions in the oxidation of phospholipids. A second approach also being pursued here is the identification of the flavor components responsible for the spoilage taste via partition chromatography. Another flavor problem being investigated is the relationship of the peptides and other products formed during casein hydrolysis to normal and off-flavors in cheese.

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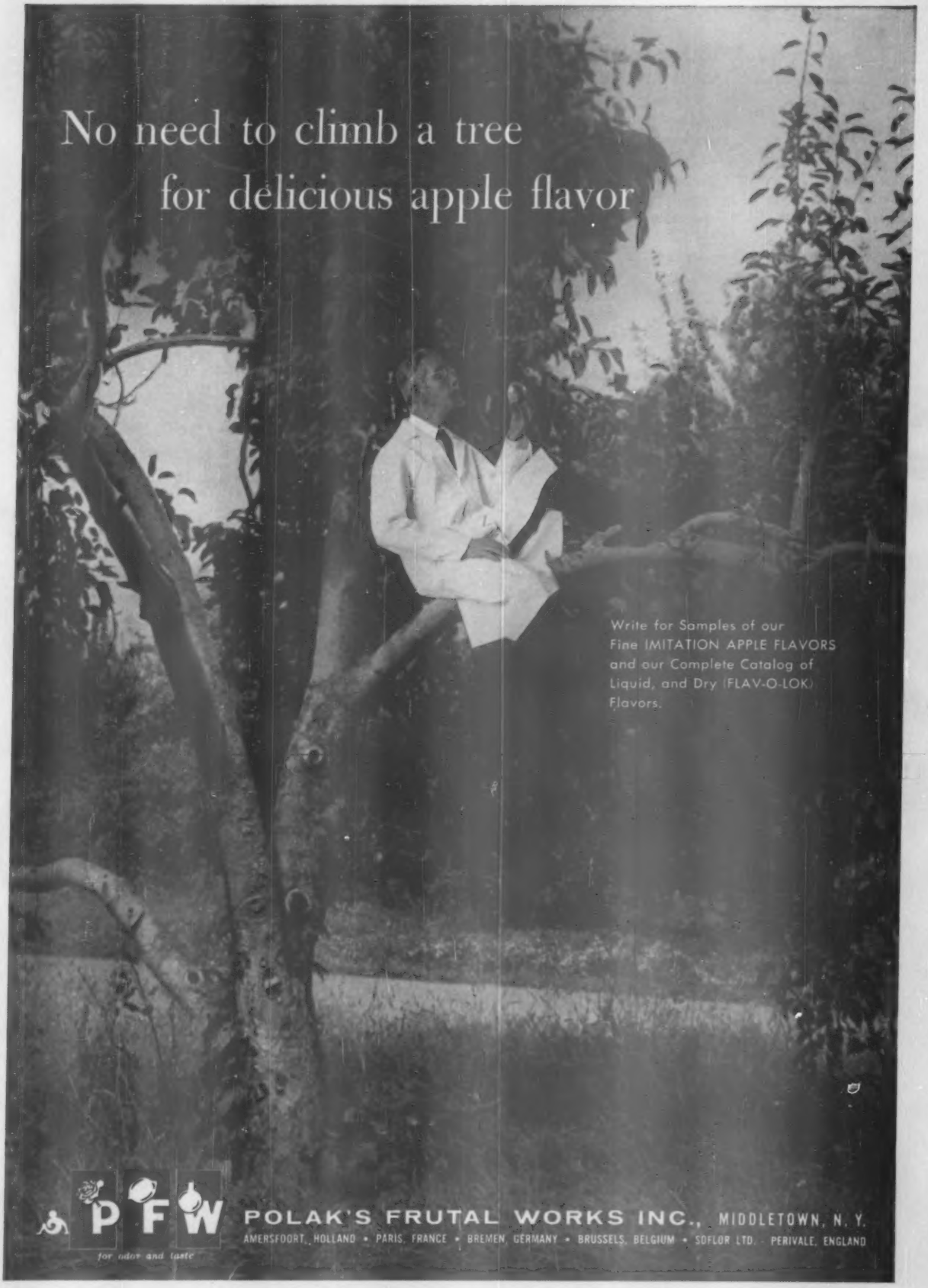
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The hydrolytic products are being characterized in an electrophoresis apparatus constructed in the laboratory.

In the bacteriological section, various programs relate to abnormal gas formation in cheese, time-temperature relationships in pasteurization, production of sterile milk, and again a flavor problem: production of a uniform, typical aroma in butter. This last problem centers about the relations of the possible citric acid to diacetyl conversion by *Leuconostoc* types, the ecological factors favoring growth of *Leuconostoc* over other bacteria, and the metabolic pathway of the diacetyl formation.

The technology section investigates problems in engineering and in storage life of dairy products such as milk powder and canned process cheese (21 storage rooms permit temperatures of +40° to −40° C. and humidities to 98%). Equipment for small scale operations and for special purposes is located here (Figures 15, 16).

The institute factory has the function of proving commercially the operations which may first be suggested by pilot plant testing. In order to keep the skilled staff on hand, the factory engages in daily production of butter and cheese (it has contracts for the delivery of a minimum of 3 million kg. of fresh milk per year). The butter and cheese is either sold at market prices or used for experimental studies in storage. Experimental potentialities of the factory reside in the possibility of altering storage conditions in its large curing rooms and in the spatial possibility of setting up different kinds of machinery in parallel for comparative purposes.

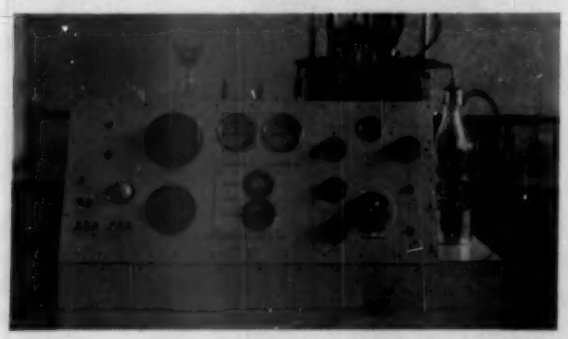


Figure 15. Micropasteurizer in the pilot plant of NIZO. Experimental pasteurization of minute quantities of milk is possible with this instrument.

Other food research. There exist several small, private laboratories in the Netherlands, some of which will do occasional research for a food processor. One of the more outstanding of these is the Netherlands Institute for Public Nutrition, under the direction of Prof. (Emer.) B. C. P. Jansen, who first isolated pure thiamine. Although much larger in the past, when its main laboratory was located at the University of Amsterdam, it now has a staff of about 10 workers, some of whom work in the animal laboratory at the University. The institute is temporarily housed with Dr. Nieman's institute for licorice research.

The principal type of investigation carried on by this group is nutritional research: the relationship of the nutritional value of food products to the type of processing to which they have been subjected. It has done much work on butter and plant fats from the nutritional standpoint. In the past, it has investigated the effects of phosphoric acid on metabolism (for a soft drink manufacturer) and the toxicology of various fat-soluble dyes which were suggested for use in chewing gum.

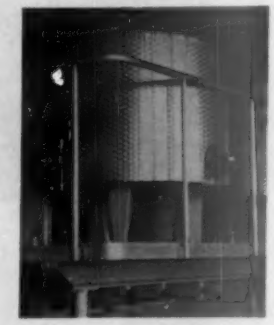


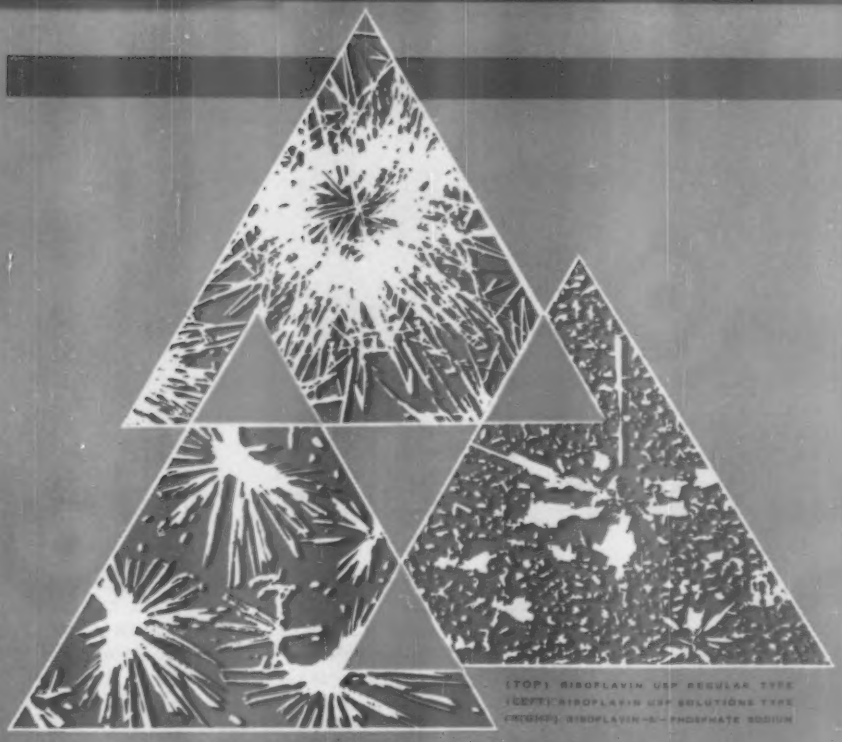
Figure 16. Stainless steel equipment, tiled floors and walls are notable features of both pilot plant and factory of NIZO. These are tanks for receiving fresh milk.

Most of the funds of the laboratory are derived from payments for the work done. However, there is still a continuing annual support from the interest on the original trust funds of the institute, and governmental grants are occasionally given it for specific research problems. Prof. Jansen is the current president of the Netherlands Society for Food and Nutrition Research (the Dutch organization of workers in the field of food science, technology, and nutrition).

Evaluation. On the whole, the heavy bias of food investigation in the Netherlands is in the direction of applied research. This fact, however, is a concession to the backwardness of the industry rather than an indication of the abilities of the Dutch scientists. The workers are eminently capable, thoughtful, and keenly aware of current trends and methods in scientific research. They have admirable research facilities, including new buildings with modern equipment. Instrument makers with exceptional skill provide them with necessary tools for their work. (Much equipment in the laboratory, as well as in the factory, has been ECA-contributed, and everywhere the writer has heard expressions of heartfelt gratitude at the timing and amount of this critical aid program.)

As in many other activities, American ideas and techniques in food technology are welcomed in the Netherlands. However, the writer found a deficiency in techniques of organoleptic appraisal, which have been well-developed in the United States. This is particularly anomalous in the face of the acknowledged emphasis on flavor problems in many research programs in the Netherlands. Evaluation of flavor is often performed on a non-statistical, subjective level. Considerable improvement could be effected here in the use of the tasting method as an analytical tool.

The relative newness of many of the institutes and their buildings is a tribute to the somewhat belated recognition of the significance of the food-processing industry in both the economy and health of the Dutch nation. It may certainly be expected that significant contributions to food science will come from these institutes.



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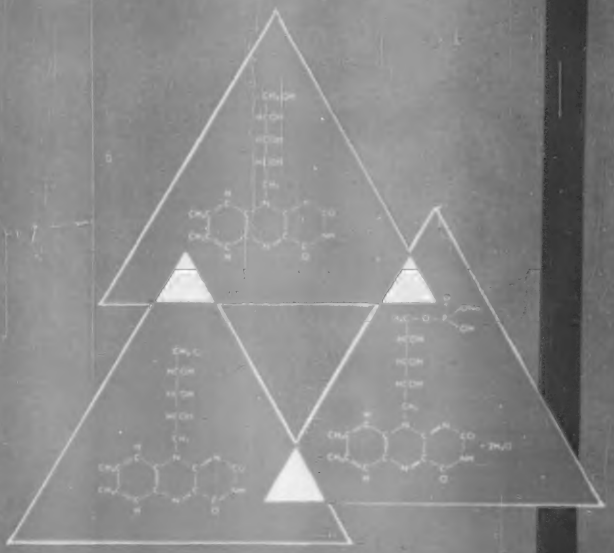

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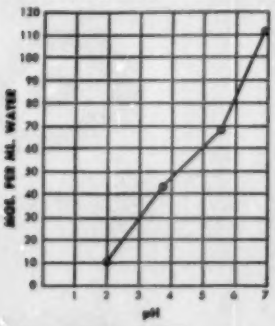

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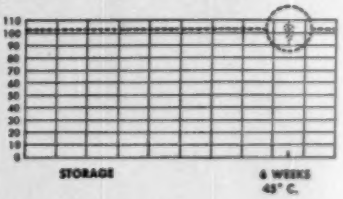
Chart demonstrates stability of Roche product in B-complex parenteral solutions with and without vitamin C over wide potency range.



uses

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The Liquilizer—a New Idea in Liquid Sugar Systems*

Frank N. Rawlings
Director of Research, Amalgamated Sugar Company

THE STORY OF the development of the "Liquilizer" is being unveiled tonight before your organization because of your wide representation in the various phases of food production and sugar consumption. In addition, you are located in one of the country's large centers of prepared food production—Chicago.

The "Liquilizer," which provides for the unloading of granulated bulk sugar deliveries, adds another chapter of progress in making available economies in sugar handling. We believe that many of you represented here may find application for this Liquilizer method. Your applications may go beyond its usage for sugar, as will be discussed later.

To adequately disclose the story of the Liquilizer it is necessary to look at the history and philosophy of liquid sugar distribution. Something over 20 years ago liquid sugar distribution had its inception in the New York area. A few far-sighted persons foresaw the economies of the handling of fluid sugar products. They could see that the delivery and handling of sugar in liquid form via metal storage tanks, pumps and pipe lines would lead to several economies and conveniences; namely:

(1) Delivery and storage in permanent metal vessels, eliminates in large measure the cost of disposable packages previously resorted to.

(2) Maximum sanitation is possible in the closed system delivery and handling of liquid sugar.

(3) Substantial customer in-plant labor and equipment economies result from the "pump and pipe" method of handling liquid sugar within the customer's plant.

As an example, the typical customer previously received a car of bagged sugar. The bags had to be manually transferred to hand trucks or lift trucks, transported to a warehouse to be manually restacked for storage. At time of use they had to be manually unstacked and trucked to point of use. The bag had to be opened and dumped and the bag disposed of.

In a typical liquid system a tank car or tank truck of liquid sugar arrives at the customer's plant, where a power pump quickly transports the liquid sugar via pipeline to the storage tank with little human attention. At time of use an automatic pump and meter deliver the desired amount of liquid sugar quickly to the point of use. This addition of liquid sugar may take place while other manually-added ingredients are being placed in the batch. No manual handling of the sugar is involved.

This device, developed by The Amalgamated Sugar Company of Ogden, Utah, is expected to revolutionize the marketing of liquid sugar. It is the Liquilizer, and it makes bulk beet sugar into liquid, as the sugar gradually drops from a hopper rail car. Frank N. Rawlings, Amalgamated research director, holds the device, which he helped develop. It bolts easily to the bottom of a hopper sugar car.

A disadvantage of this original concept of liquid sugar handling was that the liquid sugar could be made only at the sugar factory or refinery and because of the freight charge on the water portion of the liquid sugar (roughly one-third of the weight of the liquid sugar) it could only be delivered within a reasonable mileage radius around the sugar factory or refinery. Also, the original concept of liquid sugar called for diverting a portion of the plant's process solutions to liquid sugar without the purification of crystallization. These products did not have the full purity of crystallized sugar which for some uses was a handicap. This disadvantage was subsequently reduced by adding special purification steps for the sugar solutions going to liquid sugar.

The Amalgamated Sugar Company was at a particular disadvantage with respect to liquid sugar deliveries. The company plants are all located in rural areas, too remote from the areas where their sugar is consumed industrially to allow the economical delivery of liquid sugar produced at the plants.

Meeting the problem

To meet this problem and allow our company to provide some of its industrial customers with liquid sugar the company in 1952 devised a new system of liquid sugar delivery. The system provides for delivery of bulk granulated sugar to a distribution station in an area of heavy industrial sugar consumption. At this distribution station the sugar is unloaded into bulk sugar bins from which it is withdrawn and liquefied as

* Presented before the Chicago Section of IFT, February 11, 1957.

required and delivered in a limited radius around the plant by tank car and tank truck. Distribution plants of this type have been installed at Portland, Oregon, Seattle, Washington and Ogden, Utah.

This system provides a liquid sugar equal in quality to granulated sugar, which can be delivered economically into areas with a sufficient concentration of industrial sugar consumption to justify the installation and operation of such a station. The capital outlay for such a station is substantial. It should be remembered that this does not mean that the total industrial consumption of the area will carry a distribution station. It means rather that the share of the market that one company can expect to hold will justify the station. This is important if a competitive offering in the area is to be maintained.

This development represented progress, since it offered a means of offering liquid sugar in areas of heavy industrial sugar consumption remote from a sugar factory or refinery. It was, however, an incomplete solution. There remained many valued and deserving customers who were placed at a competitive disadvantage with their counterparts in the established liquid sugar areas because they could not have the economies of liquid sugar.

A method had already been placed in operation in several plants whereby bulk granulated sugar was delivered to the customer's plant. The bulk granulated sugar was conveyed into the customer's plant and stored as bulk granulated sugar to be melted in the customer's plant to liquid sugar and conveyed and used in the customer's plant as liquid sugar. This method has the disadvantage of requiring bulk granulated sugar conveying and storage equipment with a relatively high capital cost.

Recognizing the need for a solution to the problem of providing a method for offering liquid sugar to individual industrial customers located anywhere in the company's selling areas, the Amalgamated Sugar Company undertook research in 1954 to find a solution.

Since bulk granulated sugar delivery provides the most economical method for delivering pure sugar it was conceived that bulk granulated sugar delivery to the customer's door would form the basis of the method developed. This can be rail car or truck bulk granulated sugar delivery.

The objectives of the new research then were to develop a method:

a. With low or moderate capital cost.
b. With a simple mistake-proof operation.
c. With inclosed sanitary sugar handling.
d. A method that would lend itself to installation in most any plant location without elaborate changes of facilities.
e. A method fast enough to complete the unloading in a short enough time so as not to unduly tie up track or unloading dock areas. A method fast enough not to require multiple shift unloading.
f. A method requiring only the normal facilities of power, water, etc. to be found available on the premises of most any sugar customer.

If an economical system were to be developed for unloading bulk granulated sugar it was axiomatic that the minimum of high capital cost scroll and elevator conveying of granulated sugar be involved. This requirement would be satisfied to the maximum degree if the granulated sugar could be converted to a fluid product at the outlet of the car or truck.

It was also considered necessary that the process developed should not require substantial heat exceeding the nominal amount of steam and hot water available in some food processing concerns. The desire for a cold dissolving system was also prompted by the fact that the storage of warm liquid sugar presents serious problems of condensation in the free space above the liquid sugar. Such condensation diluting surface of the liquid sugar, coupled with the warm temperatures of the liquid sugar, would present bacteriological problems. Heat exchange capacity for cooling hot dissolved liquid sugar is expensive.

Experimental background

The experimental program was initiated, directed toward the above stated objectives. It was first established experimentally that at temperatures of 60 to 75° F. (optimum storage temperatures for liquid sugar) that sugar can be dissolved to essentially saturation without the presence of excess sugar. This can be accomplished with reasonable mechanical agitation in a period of 45 minutes. This demonstrated that a practical cold dissolving process is possible.

At the density of conventional liquid sugar the specific gravity of the liquid sugar approaches that of the granulated sugar. This means that only a modest mixing action either in a tank or pipe line is necessary to keep the sugar crystals thoroughly suspended. This offered two features that were utilized in the final process design.

(1) It made possible the pumping of the incompletely dissolved sugar solution.
(2) It made it feasible to finish the dissolving of the sugar in a large tank employing only a single impeller mixer.

With the above outlined background material at hand a decision was reached to attempt to devise a blending apparatus which could be portable for fastening to the outlet of the railroad car or truck. Water would be supplied to this apparatus and the mixture of sugar and water would be pumped away from the apparatus to a liquid sugar storage tank fitted with an impeller where the dissolving of the sugar would be completed.

In the course of the experimental work a principle was tried whereby a pump of a fixed capacity supplied water to the dissolving device. A pump of larger capacity was connected to the outlet of the dissolving device. It was discovered that by properly relating the capacity of two pumps employed in this fashion and utilizing a unique design of blending receptacle that a self-regulating proportioning and blending of sugar and water is accomplished. The partially dissolved mixture of sugar and water is readily pumpable and can be so conveyed by pipe line to a storage tank where an

(Continued on page 24)

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VANILLA LABORATORIES, Inc., ROCHESTER, N.Y.

SPECIAL FLAVORS FOR PREPARED CAKE MIXES, PREPARED ICINGS AND PUDDINGS

(Continued from page 22)

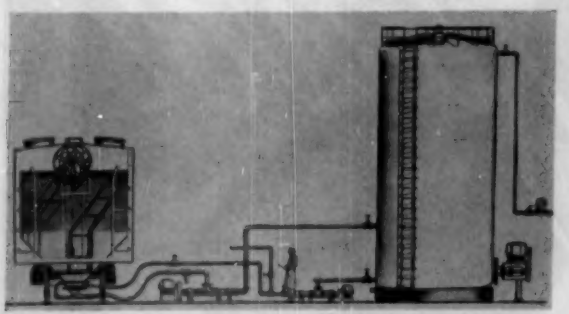
agitator completes the dissolving to result in the finished liquid sugar.

A pilot unit of this type was installed to operate in conjunction with the Portland liquid sugar station. The experimental work was carried on there to test modifications of design and to develop the knowledge of the principles of operation.

Based on this work a design was worked out. The system consists of a light alloy metal Liquilizer which can be attached by one man to the outlet flange of the delivering rail car or truck of granulated sugar. This Liquilizer is attached to the liquid system by flexible hoses coupled with snap-on fittings.

The Liquilizer is attached to the liquid storage tank via two pumps. One pump pulls from the storage tank to the Liquilizer bearing solution to mix with the dry sugar in the Liquilizer. The second pump carries the sugar-bearing solution from the Liquilizer to the storage tank. Before a car or truckload of granulated sugar is unloaded, dissolving water is metered into the liquid sugar tank to match the weight of sugar to be delivered and result in the desired density of liquid sugar.

As an example, if the bulk car of sugar carries 100,000 pounds of granulated sugar then 50,376 pounds of water, or 6050 gallons, is metered into the liquid sugar tank to convert the car to 66.5 Brix liquid sugar.



This is a schematic drawing of The Amalgamated Sugar Co.'s Liquilizer process, a system which is expected to revolutionize the marketing of liquid sugar. Approximately 144,000 pounds of bulk beet sukar can be converted into liquid in five hours. Above (at left) is a standard railroad hopper car, to which 25-pound converter is attached at the bottom. This allows sugar to drop down to where it meets water which is pumped and sucked past converter and then back to storage tank at right. Top pipe from tank leads to pump and to converter and lower pipe carries sugar-water back to tank. Agitator (lower right on tank) keeps stirring up mixture, which may go back through converter at bottom of rail car 10 or 12 times, until all bulk sugar is emptied from the car.

After the water is metered into the liquid storage tank and the Liquilizer is in place the pumps are turned on, which starts a circulation of the pre-measured water through the Liquilizer. The gate on the sugar car is opened without any necessity for attempting to regulate the rate of flow of the granulated sugar. The Liquilizer is self-regulating and will take sugar only at a fixed rate based on the design. The design need not proportion the water and sugar in exact proportion to the final liquid sugar to be produced. The liquid in the storage tank courses a closed cycle from the storage tank to the Liquilizer and back to the storage tank. Since the water has been pre-measured to match the total volume of sugar in carrier this circulation need only be continued until the sugar is completely unloaded and the Brix of the final liquid sugar is assured.

This system was refined during development to the present commercial Liquilizer system.

Commercial Application of the Liquilizer

To keep the Liquilizer process under company supervision during its initial commercial operation the first installation was made at the distribution plant at Seattle, Washington, completed in April 1956.

From the beginning this installation operated satisfactorily. No major changes of design were required. Minor adjustments reduced the unloading time for a 1300-1400 bag bulk rail car of sugar to 5 or 6 hours. The dissolving water is tempered to a temperature which will result in a sugar solution with a finished temperature of 65–75° F. so that the complete dissolving of the sugar can be accomplished within about an hour after the sugar unloading is completed.

A second commercial installation was made in the distribution plant at Ogden, Utah. This was followed in rapid succession by customer installations of the Liquilizer in Wichita, Kansas, Milwaukee and Neenah, Wisconsin.

Economics

Liquilizer Installation Cost Compared to Other Delivery Methods. The basic Liquilizer installation calls for a primary dissolving tank, having a capacity for holding the liquid sugar resulting from a maximum bulk car delivery of 140,000 pounds.

Current cost of an installation of this type is in the range of $12,000 to $15,000, without including the cost of building for enclosing the installation, if required. In many areas and for some seasonal uses the installation can be made outdoors. Such an installation is practical the year around outdoors in a climate as severe as Seattle, Washington.

The above-stated cost will cover a turn-key job, including the liquilizer installation complete with pumps, piping, wiring, meters, hoses, storage tanks, etc. If larger storage capacity is required this is not reflected by proportional increase in the installation cost since the unloading system and primary tanks will remain the same. The additional cost will be limited to the additional cost of expanded secondary storage tank facilities. This additional storage can be roughly figured currently at 30 cents per gallon of capacity. Using this as an example then, if 10,000 gallons of additional storage is required, the total cost of the installation would only be increased by approximately $3,000. The basic system outlined above will consist of an approximately 20,000 gallon tank.

Dry bulk granulated sugar installations are more variable in cost than are liquid sugar installations because in servicing multiple or distant points of use the liquid installation involves only piping while the bulk granulated sugar installation involves mechanical elevators and mechanical conveyors.

A typical bulk granulated sugar system will cost from two to three times as much as the equivalent Liquilizer installation.

Liquilizer In-plant Savings. Operationally there is

(Continued on page 26)

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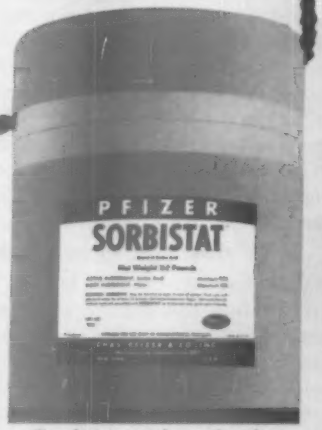

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(Continued from page 24)

small difference in cost of operating a bulk granulated sugar installation in relation to the Liquilizer installation. However, should plant expansion demand sugar at new points of use then there is a definite saving in the cost of expanding the liquid sugar system over the cost of expanding the bulk granulated system.

All bulk sugar systems, including the Liquilizer system, offer substantial in-plant savings to the customer over using bagged sugar. These benefits are derived from a saving of in-plant sugar handling labor, a saving in storage space, a saving of spillage that takes place from bagged sugar, and a saving realized from less housekeeping labor.

There is an additional value in the Liquilizer system for a customer in the sanitation of the Liquilizer system as compared to bagged sugar. In modern food processing this is of real tangible value. Figures on this dollars and cents saving which a customer realizes in using the liquid sugar have been developed for numerous applications. Depending upon his previous method of handling bagged sugar, a customer may save anywhere from five cents a bag to as much as forty cents per hundred weight of sugar as a direct in-plant saving.

Bacteriological control

The question of bacteriological control with the Liquilizer system will enter the thinking of liquid sugar consumers. These installations are designed consistent with our standard liquid sugar precautions and sanitation practices.

The following represents a compilation of 15 consecutive weekly bacteriological analyses on liquid sugar delivered from the Seattle liquid sugar station:

All 15 samples were negative for flat sours, total thermophiles and yeasts. Twelve of the 15 samples were negative for molds. Two samples were counted between one and five molds per ten grams of sugar. One sample was in the range of 6–10 molds per ten grams.

Masophile counts on these samples show four samples in the range of 6–10 per ten grams of sugar, three ranging 11-15, four 16-20, two 26-30, one 36-40 and one plus 40.

Other Uses for the Liquilizer

The Liquilizer will not be limited in usage to sugar alone. Any bulk commodity which can be shipped in bulk granulated form, and is to find use in solution, can be unloaded via Liquilizer. This will be true whether the dissolving medium be water or other solvent.

If abrasive resistant pumps are available products may be unloaded which are not soluble but will be used in slurry form.

Test unloading has already been carried out whereby di-ammonium phosphate, shipped in bulk, has been converted to liquid fertilizer via the Liquilizer. Examples of products which may be handled with the Liquilizer are salt, sodium sulfate, urea, potash salts, etc.

Future Plans for the Liquilizer

Patent applications on the Liquilizer have been filed in a number of countries and the question arises how these patents will be administered.

The basic objective of our company in this research and development was to find a practical way to offer to their customers liquid sugar without geographical limitation.

The company's program for the sustained development of the Liquilizer calls for continued development of the process through the year 1957. By the beginning of 1958 the company expects that the Liquilizer will be thoroughly enough tried and on a sound enough footing to justify making it available to the other sugar companies through a nominal license arrangement. With this program the company feels the Liquilizer will be most soundly developed and offered for the greatest good.

NEW YORK . . .

Continuing the theme of new product development, Dr. George Garnatz addressed the New York Section at its meeting at the Brass Rail Restaurant on April 20th on the topic "The Effect of New Products on Our Living."

Tracing briefly the early progress in improving human nutrition through fortification of foods with minerals and then vitamins, Dr. Garnatz, president of IFT during 1956–57 and head of the Kroger Food Foundation, illustrated how food technology is now helping create new products and improve existing ones. Examples included tenderizing meat in forty-four hours by the use of enzymes, instead of the two to three weeks required by conventional aging methods; application of good refrigeration, including control of humidity, to make fresh produce more widely available for longer periods of time; the continuous pressure cooker which both speeds production and improves quality; and development of the aseptic canning method which results in marked improvement in quality.

As a result of improved technology, production, and distribution, continued Dr. Garnatz, the homemaker now spends only about one hour and thirty-six minutes in the kitchen to prepare a day's food for a family of four, whereas about thirty years ago, she required five and one-half hours to accomplish the same chore.

It is significant also, Dr. Garnatz pointed out, that today we are eating more food per capita, but consuming fewer calories. What is more, our diet is better balanced, containing more of the essential nutrients which make for a healthier and longer life.

"There is no end in sight to the upward trend in food quality and variety," according to Dr. Garnatz. "In the fields of food production, processing and distribution, there are still so many things to learn, conditions are so fast-moving and competitive that increasingly great sums are being invested in research and product development so that technical advances may continue at an ever-increasing pace. The trend is in the direction of streamlining, making continuous and automatic methods of food processing and preservation." Projecting into the future, Dr. Garnatz referred to one-day curing of bacon, improvements in frozen-meat mer-

(Continued on page 28)

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Other Entrapped Flavors Developed on Request.

Suggested uses per 100 lbs.:

Gelatin Dessert: Orange—Lemon—Lime—2½ to 3 oz.
Other flavors: 1¾ to 2 oz.
Cake Mixes: 2 to 4 oz.
Puddings: 2 to 3 oz.
Powdered Drinks: (without sugar) 12 oz. to 16 oz.
(1 oz. makes 2 qts. finished beverage)
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Standard Packing: 150 lb. containers

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Cloudy Lime
Cloudy Lemon-Lime

Suggested Uses:

Syrups ..... ½ oz. per gal.
Lemonade Mix ..... 6 to 8 oz. per 100 lbs.
Lemon Bar Mix ..... 6 to 8 oz. per 100 lbs.
Powdered Drinks (without sugar) ..... 2 to 2½ lbs. per 100 lb. Mix—1 oz. makes ½ gal. Finished Beverage

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(Continued from page 26)

chandising, antibiotic preservation of foods, production of bread by a continuous process, and the application of atomic energy and radiation to food processing.

"Now, as never before, the value of scientific research is appreciated so that all of our resources for discovering new knowledge in the fields of food production, processing, distribution and nutrition, are being marshalled and augmented for the job ahead. Thus will the attributes of human knowledge, skill, provision and ingenuity be brought to bear on these problems so that the quality of food may be continuously improved and so that people may not only be well-fed but properly nourished."

Prior to the presentation of the principal address, Dr. Garnatz and Col. Charles S. Lawrence, Executive Secretary of the IFT, spoke briefly on Institute affairs, emphasizing efforts and progress in the educational and public relations activities at both national and section levels.

WESTERN NEW YORK . . .

The Section held its annual Spring Meeting on Friday, April 26, 1957, at the New York State Agricultural Experiment Station, Geneva, N. Y. During the morning the Department of Food Science, with Professor R. L. LaBelle in charge, held Open House and displayed exhibits. Luncheon was served at the LaFayette Inn, Geneva. In the afternoon, after the Welcome by Dr. A. J. Heinicke, Station Director, the following papers were given:

"Aspects of the World Food Situation," Dr. David B. Hand, Food Conservation Officer, UNICEF, United Nations. (Head, Department of Food Science and Technology, New York State Agricultural Experiment Station, Geneva. On leave).

"Antibiotics in Food Preservation," Dr. Walter L. Clark, Food Technologist, American Cyanamid Co.

"The Food Technology Curriculum at Cornell," Dr. E. A. Nebesky, Associate Professor of Food Technology, Cornell University.

"Research in Food Science and Technology at Geneva," Dr. Carl S. Pederson, Acting Head, Department of Food Science and Technology, New York State Agricultural Experiment Station, Cornell University, Geneva, N. Y.

SOUTHERN CALIFORNIA . . . .

SCIFTS warmly welcomed congenial Roger V. Wilson of the Chicago section to the April meeting at the Rodger Young Auditorium in Los Angeles. Dr. Wilson is well-known among food technologists throughout the country through his long association with Continental Can Company where he is presently General Manager of the Customer Research Division.

As guest speaker, Dr. Wilson reviewed the newer developments in packaging. He first stressed the importance of packaging not only for the protection of the food and therefore the health of the consumer, but also to attract and retain sales. He pointed out that the American homemakers serve as the dictators for changes in packaging as the processor attempts to "give the lady what she wants." Along the lines of convenience packaging much throw-it-away packaging has evolved; a more easily removed metal strip for sealed tins has been developed; cardboard cartons have been produced with a string cutter to discard part of carton when the contents were partly used; foil-laminated cartons to be made into trays have recently been introduced; and many other eye-catching and convenience packages are being produced.

WISCONSIN . . . .

The Wisconsin section of the Institute of Food Technologists was granted its charter by the national organization at a banquet meeting held Friday evening, March 29, at the Cuba Club, Madison.

Shown above (left to right) are: B. Foote, executive vice president of Red Star Yeast Co. of Milwaukee, and guest speaker at the banquet; George Garnatz, director of the Kroger Food Foundation, Cincinnati, and president of the National Institute of Food Technologists who presented the Wisconsin group's charter to Dr. William J. Shannon, assistant vice president of Oscar Mayer & Co., Madison, and chairman of the Wisconsin section of the Institute.

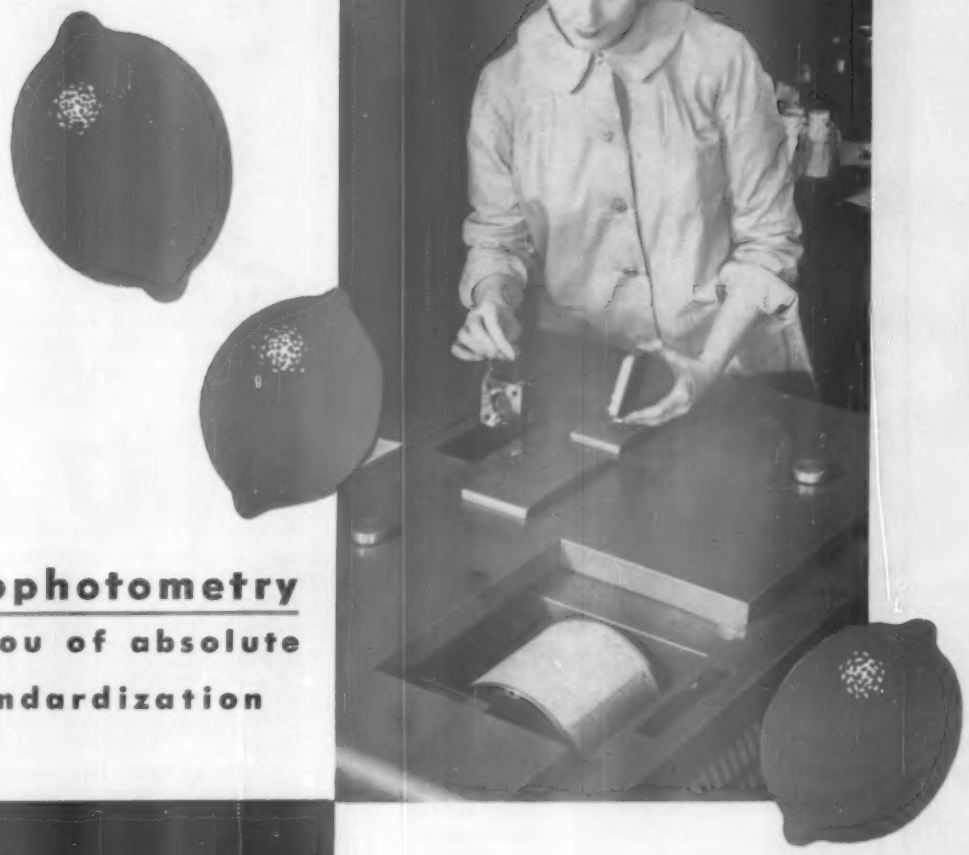
The Wisconsin chapter has 130 members within its section which includes the entire state of Wisconsin. Officers of the local section are: Shannon, chairman; Prof. Paul Buck of the University of Wisconsin, secretary-treasurer; Harold Steinke, Lake-shire-Marty Co., chairman-elect; and Prof. Kenneth Weckel of the University of Wisconsin, councilor.

Foote spoke on "What Management Expects of Research."

DIXIE . . . .

The Annual Meeting and Election of Officers of the Dixie Section was held 26 April 1957 at the Cherokee Room, Atlanta, Georgia. The following officers were selected to serve the coming year: Chairman, A. S. Perry; Vice-Chairman, Cyril Lovvorn; Sec.-Treas., William B. Cown; Councilor, Dr. J. G. Woodroof; and Editor, Miss Cordelia Ellis.

(Continued on page 30)



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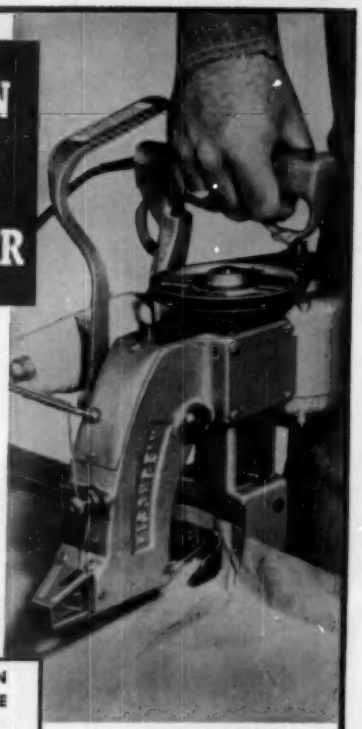

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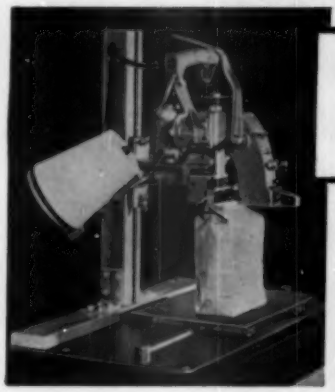

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(Continued from page 28)

Following the business meeting a very excellent and timely program on cholesterol and its metabolism was conducted by Dr. John Atwater and Dr. Walter Bloom. Dr. Atwater, a diagnostician specializing in gastroenterology, discussed the clinical aspect and Dr. Bloom, an authority in the field of medical education and research, presented the biochemical view. It was pointed out that heart attacks, strokes, diabetes, and hypothyroid conditions account for more disability and deaths than any other ailments. In nearly all such cases, an increase in blood cholesterol has been noted. In many instances the increase in cholesterol is due to synthesis within the body and is not necessarily a reflection of intake of foods of high cholesterol content. Also, the ability of individuals to tolerate high cholesterol intake and high cholesterol levels varies considerably. It was stressed that strict diet and elimination of consumption of foods containing appreciable cholesterol should be considered on an individual basis and only then on the advice of the physician.

It was concluded by the membership that the food industry should proceed with caution in promoting foods on basis of low cholesterol content until additional and more conclusive information has been obtained.

BRITISH COLUMBIA . . .

The regular meeting of the Section was held in McGavins Auditorium in Vancouver, B. C., on Friday, March 29.

Chairman Larry Devlin introduced our guest speaker, Dr. Emil M. Mrak, Chairman, Department of Food Technology, University of California at Davis.

Dr. Mrak outlined the organization of the Department at Davis, emphasizing the teamwork obtained between the Technologist, the fundamental scientists and the agricultural scientist. Developing this theme with examples, Dr. Mrak showed how his group had attacked problems in canned pears, cling peaches and asparagus, arriving at solutions of considerable economic value to California canners. Dr. Mrak pointed out the need for increased cooperation between Food Technologists and agricultural scientists in the solution or prevention of processing problems, using the citrus root stock in California as one example.

A most active question period followed with questions ranging from "blue" pears to academic curricula. Dr. Nora Neilson thanked Dr. Mrak, pointing out that the objectives of the undergraduate Food Technology course at U. B. C. were quite similar to those being sought at Davis.

Elections for next year's executives were held. Officers elected were:

Councillor: Dr. Paul Trussell, B. C. Research Council.
Chairman: Mr. E. Watson, Dept. of Ag. Engineering, U. B. C.
Vice-Chairman: Mr. C. Bullen, Harrison & Crosfield Ltd.
Secretary: Dr. Nora Neilson, Dept. of Dairying, U. B. C.
Treasurer: Mr. M. Woodley—Jersey Farms Ltd.

Mr. C. Bullen, banquet chairman, spoke briefly on the arrangements for our annual banquet to be held in Stanley Park Pavilion on Tuesday, May 14, 1957.

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IFT ACTIONS AND REACTIONS . . .

FOOD TECHNOLOGY COURSES INTRODUCED AT CITY COLLEGE OF NEW YORK

Two Food Engineering courses at the graduate level and two new courses in technology for food industry personnel with or without academic background are being offered in 1957–58 by City College of New York. Dr. S. S. Lichtblau, Department of Chemical Engineering, is the instructor in charge of the four courses.

Guest lecturers for the Food Technology and Confectionery courses will be Mr. Samuel Goldstein, Drs. V. G. Fourman, M. B. Sherman, S. Zuckerman, and B. L. Oser. Dr. Amihud Kramer will be a guest lecturer in Food Engineering II.

The course in the Fundamentals of Food Technology is directed particularly toward production workers, laboratory technicians, and administrative and advisory personnel. Content of the course includes chemical and physical concepts as applied to food constituents, flavor chemistry, color in foods, instrumentation, and such unit operations as heating, cooling, freezing, mixing, pumping, etc. All courses are given in the early evening hours.

FOOD INDUSTRY TOPICS . . .

. . . in the public interest

Solace for ulcer sufferers comes in a report of new research showing that certain spices are not harmful to ulcers. Placed on the "permissible" list for those with active duodenal or gastric ulcers are cinnamon, allspice, mace, thyme, sage, paprika and caraway seed.

Writing in the *American Journal of Gastroenterology*, Dr. Max A. Schneider of Buffalo, Dr. Vincent DeLuca, Jr., of Derby, Conn., and Dr. Seymour J. Gray of Boston have reported the results of tests on 50 ulcer patients.

"One of the problems of diet therapy in peptic ulcer disease," the doctors explained, "is the unpalatability of the diet, with resultant lack of patient coöperation."

The tests consisted of feeding 0.05 to 0.9 grams of spices in capsules three times a day over periods of two weeks to five months. The average testing period was 40 days. The amount of spice used in each case was determined by the requirements of spiced recipes from *The A-B-C of Spice Cookery*, published by the American Spice Trade Assn., which sponsored the research.

As long as they were taken with food, the spices listed above caused no discomfort and did not alter the healing time of the ulcer craters, according to the report. However, as was expected, the seasonings tended to cause distress when taken on an empty stomach between meals. During the tests the patients were kept on the usual ulcer diet, interval feedings, antacids and antispasmodics. At no time did the patients know which spice or the quantity they were receiving.

◆ ◆ ◆

Every year total taxes are taking a bigger bite out of the family income than most people realize. According to Paul S. Willis, president of the Grocery Manufacturers of America, people tend to think of taxes mainly in terms of income taxes. But these, he pointed out, are only part of the total taxes a family pays annually.

"Americans are spending roughly the same percentage of their incomes on food as they did ten years ago," Mr. Willis said, "but the percentage of their income taken by taxes has been steadily increasing.

"The price of food and grocery products is, of course, affected by these taxes. Out of every $5 a family spends for groceries, $4 pays for groceries, $1 pays for hidden taxes."

Mr. Willis called attention to the fact that until World War II the national food bill was much bigger than the tax bill. "Since then," he said, "there has been an alarming increase in taxes each year, as is evidenced by the fact that in 1957 the annual tax bill will be around $100 billion. This is one-third larger than will be the total consumer expenditures for food —about $73 billion."

◆ ◆ ◆

The American Spice Trade Assn. has announced development of a new method for determining the quality of natural black pepper. Based on the piperine content of the spice, the new test is said to provide a more accurate, simpler and faster way of gauging the quantity of piperine present. Piperine is the principal substance associated with pungency and bite strength in pepper. This test, coupled with a recently developed method of analyzing volatile oil, the aromatic factor in black pepper, now makes it possible to measure more accurately the flavor of this spice, according to the association.

The new test, a modified colorimetric procedure, measures piperine by determining color developed with special reagents, and is reported to be a major improvement over the existing method of estimating piperine by nitrogen level.

The colorimetric acid analysis was developed by Leonard A. Lee, a research associate of the ASTA and a staff member of the Eastern Utilization Research Branch of the U. S. D. A.

(Continued on page 40 following technical papers)

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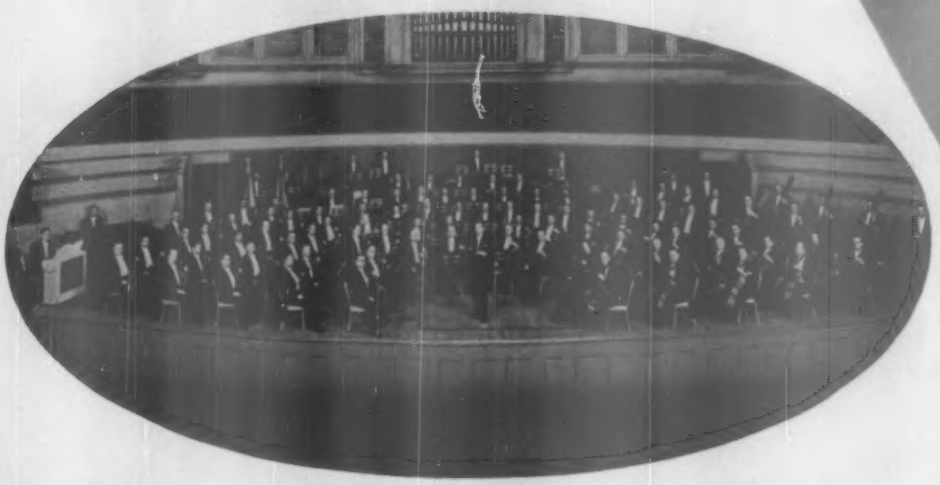

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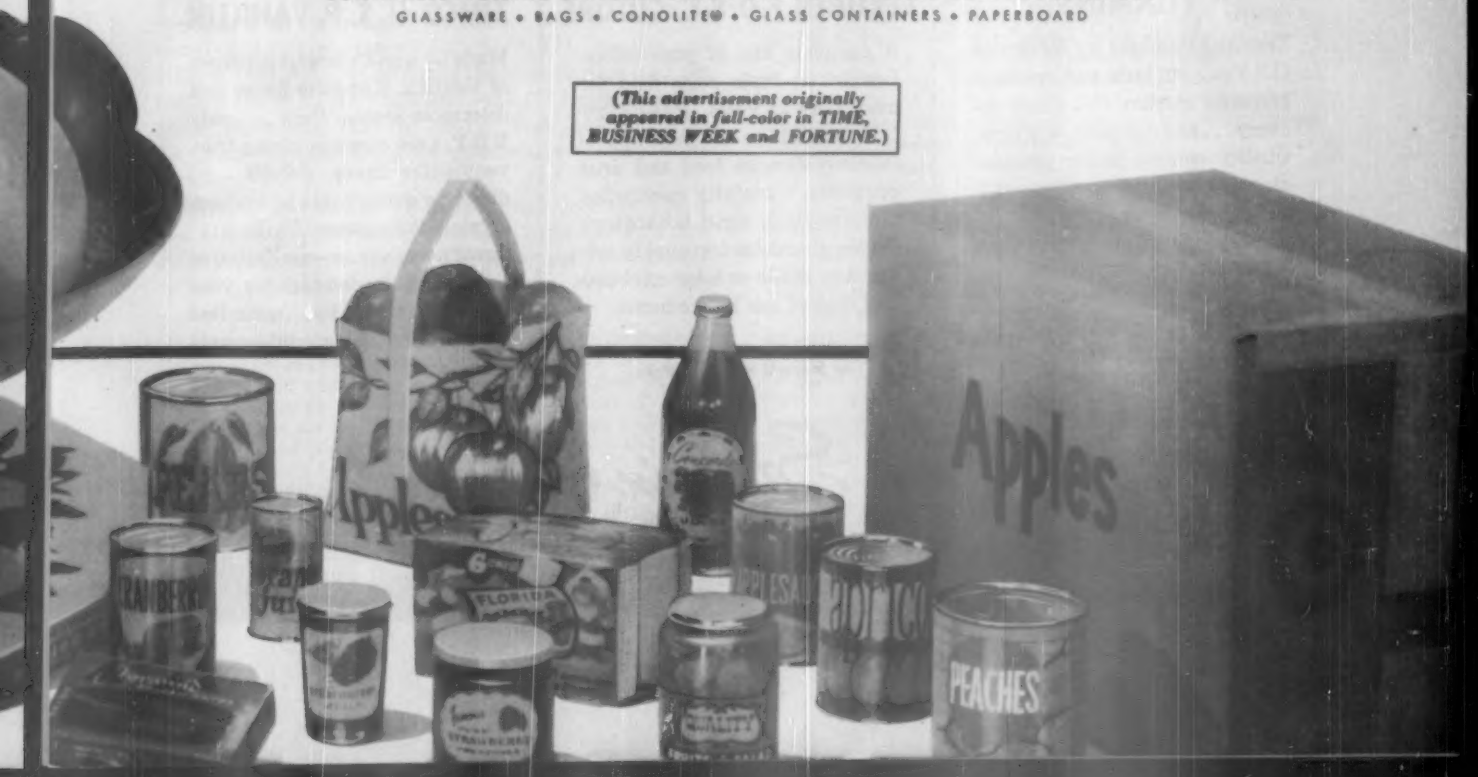

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Polyphenolic Content and Enzymatic Activity of Two Varieties of Potatoes. I. Preliminary Report[a, b]

Walter L. Clark,[c] Nell Mondy, K. Bedrosian,[d] R. A. Ferrari[e] and Catherine A. Michon

School of Nutrition, and Department of Food and Nutrition, College of Home Economics, Cornell University, Ithaca, New York

(Manuscript received November 6, 1956)

BLACKENING OR DISCOLORATION has been one of the most serious and constant problems in the production, storage, marketing, processing, and cooking of potatoes. The precursors for this darkening phenomenon, either of enzymatic or non-enzymatic nature, have been suggested as being polyphenolic substances. Some of these compounds have been known to enhance the respiration of potato tissue. Conclusions have been reached that polyphenol oxidase is responsible for enzymatic darkening and terminal oxidation. More recently cytochrome oxidase is reported to be the primary terminal oxidase in potato tissue, though responsibility for potato blackening has not been implicated.

The present study was undertaken to investigate the polyphenolic substances occurring in two varieties of potatoes by means of paper chromatography and quantitative measurements for three different stages of maturity. The Pontiac potato was chosen as a variety resistant to blackening and the Ontario as one susceptible to blackening. The cytochrome oxidase and polyphenol oxidase activities for these varieties were measured at three different stages of maturity by manometric techniques. Thus, this paper reports some preliminary data concerning the types and amounts of polyphenolic substances as well as enzymatic activity of Pontiac and Ontario varieties at three stages of maturity.

Review of the literature. Several researches have accumulated with respect to the polyphenolic constituents, tyrosine, other free alpha amino acids, catechols, and dihydroxy-phenylalanine (DOPA), that are found in the potato tuber *(6, 8, 9, 10, 11)*. Rudkin and Nelson *(13)* have reported on chlorogenic acid and the respiration of sweet potatoes. Juul *(11)* reported that ortho diphenols (caffeic acid) were associated in the stem-end darkening of potatoes, especially after cooking.

Johnson and Schaal *(10)* and more recently Cheng and Hanning *(6)* have identified tyrosine and chlorogenic acid in potato tissue. The latter authors reported caffeic acid as being present in the skin extract; chlorogenic acid was the only polyphenolic substance present in various portions of the tuber. Swain *(18)* refers to coumarins as possible precursors for enzymatic browning.

Various workers in the past *(2, 4, 5)* found that the respiration of potato tissue could be stimulated by phenolic substances and therefore concluded that polyphenol oxidase was involved in the terminal electron transfer. Schade and Levy *(14)* showed that the respiration of freshly cut potato slices was inhibited by carbon monoxide, and concluded that a major share of respiration in the potato goes through cytochrome oxidase and these facts have subsequently been confirmed by Thimann, Yocum, and Hackett *(19)*. Goddard and Holden *(8)* found cytochrome oxidase in potatoes sufficiently active to account for the total respiration of the tissue. Todd *(20)* believes that the cytochrome oxidase system is involved during the growth of the tuber, whereas during the rest period respiration is functioning via the polyphenol oxidase system. Schwimmer, in his excellent review of enzyme systems of the white potato *(15)*, mentions that very few enzyme studies have been directed toward solution of problems of the potato grower and processor.

Interest in the present work stems from the fact that no papers have reported polyphenolic content and enzymatic activity of potatoes with respect to maturity and blackening.

EXPERIMENTAL

Source and storage of raw material. The Ontario variety of potato, susceptible to blackening, and the Pontiac variety, resistant to blackening, were grown under known conditions at Riverhead, Long Island by the Department of Vegetable Crops, Cornell University, and were harvested 14, 16 and 20 weeks after planting. After harvest the tubers were stored at 4° C. for a few days before polyphenolic extracts and enzyme preparations were obtained for appropriate analyses.

Paper chromatographic analyses

1. *Preparation of potato extracts.* Two hundred grams of potato peels, a concentrated source of polyphenols, were placed in 800 ml. of cold acetone, for overnight extraction at 1–2° C. The acetone potato peel slurry was filtered with fluted filter paper. The residue of peels was blendorized with 200 ml. of cold acetone for 2 minutes in the cold room and filtered. The combined filtrates were concentrated under vacuum until 80% of the acetone was removed by means of a spinning flask (Rinco) which was supported in a warm water bath at 35° C. The concentrated extracts were placed in the cold room, 1–2° C. for an hour or two to facilitate the removal of waxes, gums, and other unwanted components. The extracts were then filtered through infusorial earth to remove any insoluble material.

2. *Purification of potato extract.* The extract as prepared above was purified by the lead acetate acid method of Rudkin and Nelson *(13)* with slight modifications. Twenty-five milliliters of 0.5M. neutral lead acetate was added to the extract from 200 g. of potato peels. The solution was mixed and then placed in the cold room for 1–2 hours to facilitate the complete precipitation of the polyphenols as yellow-colored, lead polyphenolates.

---

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 13, 1956.

[b] Report of a cooperative study between the School of Nutrition, Department of Food and Nutrition, College of Home Economics, and the Department of Vegetable Crops, College of Agriculture, and supported in part by the Research and Marketing Act.

[c] Present address: Department of Food Research, Research Division, American Cyanamid Company, Pearl River, New York.

[d] Present address: Department of Food Technology, University of Illinois, Urbana, Illinois.

[e] Present address: Department of Biochemistry, Pennsylvania State University, State College, Pa.

The lead precipitate was then dissolved in 30 ml. of 5% acetic acid and filtered. Twenty-five milliliters of 0.5M. neutral lead acetate was added to the filtrate, and the solution was brought to pH 8.5 with concentrated ammonium hydroxide. The alkaline solution was placed in the cold room for complete precipitation of the polyphenolic substances.

The mixture was then centrifuged in a 100 ml. lustroid tube and the lead polyphenolate precipitate was washed twice with distilled water. Dilute sulphuric acid was added to the precipitate to liberate the polyphenols and precipitate the lead as lead sulphate.

The solution was filtered and the filtrate was made 2 M. with respect to potassium dihydrogen phosphate and was further adjusted to pH 2.0 with dilute sulfuric acid. The solution was then extracted five times with 5 ml. portions of ethyl acetate. The water layer was saved for quinic acid analyses. Both the ethyl acetate and water extracts were stored in amber flasks in the cold room.

3. *Chromatographic assays of the extracts.* (A) *Solvent.* Butanol-acetic acid-water (4:1:5) was used as the solvent in a chamber designed for ascending paper chromatography. The solvent was allowed to equilibrate for 6 hours in a separatory funnel before the water layer was drawn off and discarded. The organic layer was used as the developing solvent and to saturate the gaseous phase of the chamber.

A 0.5 ml. portion of each of the purified extracts was applied to Whatman No. 1 paper. Standards of DOPA, caffeic acid, quinic acid, chlorogenic acid, and phloroglucinol were always employed and run concurrently with the purified potato extracts. The paper with the applied spots was then allowed to equilibrate in the chamber, which is air-saturated with butanol-acetic acid, for 6 hours. Then the organic layer of butanol-acetic acid was added to the troughs and an ascending time of 15.5 hours was allowed in accordance with Swain *(18)*.

The dried chromatograms were placed in an ammonia saturated chamber for 30 minutes. The developed chromatograms were examined and marked for fluorescent spots, representing polyphenols, under ultraviolet light. The Rf values were calculated from measurements made to the center of the fluorescent spots.

(B) *Bromphenol blue spray.* A solution of tetrabromphenol blue was found to be more effective in detecting quinic acid than was ammonical silver nitrate, ceric sulfate, or exposure to ammonia vapor. The bromphenol blue spray was prepared by dissolving 0.1 g. of the compound in 500 ml. of 0.02 N. sodium hydroxide and diluting to 250 ml. The spray was applied evenly over the entire chromatogram. After spraying, the paper was placed in a water vapor saturated chamber for 30 to 60 minutes, after which the chromatogram was examined. Quinic acid appeared as a yellow spot against a blue background. Chlorogenic and caffeic acid appeared as blue-green spots.

(C) *Borate paper.* Whatman No. 1 paper was impregnated with 0.1 M. solution of sodium tetraborate (nearly saturated) by allowing it to ascend the paper. Borate paper can be used to detect polyphenols since the borate will complex the polyphenols and depress their movement up the paper *(18, 21)*. The borate impregnated paper was then employed in the same manner as the standard chromatograms.

(D) *Enzyme spray.* A polyphenol oxidase preparation from potatoes was prepared in a similar manner as from apple and pear tissue as suggested by Siegelman *(17)*, with slight modifications. The 0.1 M. phosphate buffer (pH 6.0) used as an extractant was made 0.1 M. with respect to ascorbic acid. An initial filtration was employed using a four ply cheese cloth prior to passing the liquid through a milk filter disk. After refrigerated centrifugation at 13,000 x g for 15 minutes, the sediment was washed twice with 0.2 M. phosphate buffer (pH 6.0) made 0.1 M. with ascorbic acid. The final sediment was resuspended in 50–75 ml. of 0.2 M. buffer in an Elvehjem-Potter tissue homogenizer. This preparation was used as a spray on the dried unmarked paper chromatograms. The chromatograms were then incubated for 15 hours in a water vapor saturated, airtight cabinet. The chromatogram was then examined for brown spots which indicated substrates for polyphenol oxidase.

Quantitative analyses for polyphenolic content

1. *Sampling procedure.* Ten potatoes of each variety for each harvest were selected at random. A No. 10 cork borer, 1.6 cm. dia., was used to remove cylindrical samples, two from each potato. The samples were taken perpendicular to each other.

2. *Extraction and purification of polyphenols from potato.* The potato cylinders were sliced into disks from 3–5 mm. in thickness. These disks were weighed and placed in acetone for overnight extraction at 3–4° C. The remainder of the extraction and purification steps of the acetone extracts were carried out in the same manner as previously described, except that after the final lead polyphenolate precipitate was dissolved with dilute sulfuric acid, it was filtered and diluted to 100 ml. with distilled water.

3. *Analysis for polyphenolic content.* The nitrite-molybdate method of Arnow *(1)* and phosphomolybdic-tungstate method of Rosenblatt and Peluso *(12)* were used to determine the polyphenolic content of extracted and purified filtrates from each variety and harvest of potato. Caffeic acid was used as the reference polyphenol.

Enzymatic activity. Cytochrome oxidase and tyrosinase activity were determined using the manometric techniques described by Goddard and Holden *(8)* with several modifications. Fifty grams of cortex plus peel of the tubers (approx. 2¼ inches in dia.) were blended for one minute in 50 ml. of 0.05 M. sodium barbiturate. This material was then filtered through cheese cloth for 3 minutes, and the filtrate centrifuged at 600 x g. for 3 minutes. The supernatant liquid was used for the determination of cytochrome oxidase and polyphenol oxidase activities. All containers and reagents were chilled during the preparation of the extract.

For the determination of cytochrome oxidase activity 0.6 ml. of the potato extract was added to one side arm, and 0.8 ml. of 0.07 M. hydroquinone was added to the other side arm of the Warburg flask. The main compartment contained 1 ml. of 0.5 M. potassium phosphate buffer at pH 7.1, and 0.6 ml. of 2.25×10^{-4} M. cytochrome c. The center well contained 0.2 ml. of 2 N. sodium hydroxide. The side arm contents were added after a 5-min. equilibration period at 30° C., the stopcocks were closed, and the oxygen consumption was measured at 10-min. intervals for a 60-min. period with air as the gas phase. The polyphenol oxidase activity was similarly tested using 0.2 ml. instead of 0.6 ml. of the enzyme preparation of 0.2 ml. of 4.55×10^{-3} M. catechol instead of the cytochrome c. Water was added to make the total volume in each flask 3.2 ml.

RESULTS AND DISCUSSION

Chromatographic assays. Figure 1 portrays the results of a typical chromatogram of known polyphenolic substances and purified extracts of Pontiac and Ontario potatoes. Papergrams for each variety exhibit 5 similar polyphenolic spots. Spots a and d correspond to chlorogenic and caffeic acids, respectively, when compared

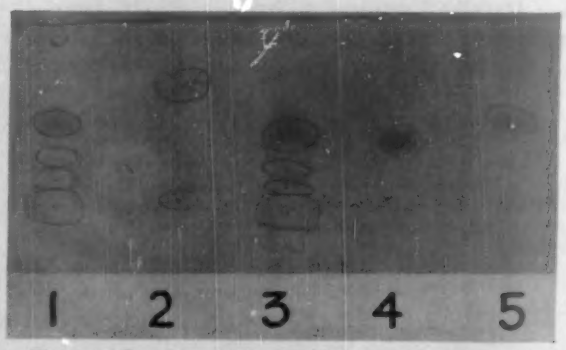

Figure 1. Papergrams of polyphenols. 1 and 3, Pontiac and Ontario extracts of peel; 2, chlorogenic acid; 4, phloroglucinol; 5, caffeic acid.

with these standards, papergrams No. 2 and No. 5.

The Rf values for these potato polyphenolic extracts are recorded in Table 1. In these chromatographic experiments, DOPA, a known polyphenolic compound

TABLE 1

Rf values of the potato polyphenol extracts

Spot No.	Ethyl acetate fraction		Known component
	Variety		
	Pontiac	Ontario	
			0.17 DOPA
a	0.52	0.51	0.52 Chlorogenic Acid
b	0.58	0.57	?
c	0.63	0.62	?
d	0.72	0.71	0.74 Caffeic Acid
e	0.98	0.98	?
	Water fraction		
aW	0.25	.....	?
bW	0.33	0.34	0.34 Quinic Acid

in potato tissue, was not found to be present. Whether the extraction and purification procedures employed are responsible is not known. The Rf values for chlorogenic, for caffeic, and for quinic acids agreed well in the extracts from the two potato varieties and also with the standards for these respective compounds. The caffeic acid values are in very good agreement with Swain *(18)*, but the chlorogenic acid values are somewhat lower as Swain reported an Rf of 0.61 for this compound. In many of the papergrams, it was observed that the standard chlorogenic acid resulted in two spots, presumably due to a hydrolysis yielding caffeic acid. Spots b, c and e were not identified.

Similar polyphenolic results were obtained for each harvest and no differences were noted between the varieties, except a water soluble red pigment found in the Pontiac. This pigment was observed in the aqueous layer after extraction by ethyl acetate. A pink to red pigment was always visible in solution and on the papergram. This compound would appear to be polyphenolic in nature because of the procedures employed. Whether a glycoside form is present cannot be ascertained by the present study. The differential solubility with ethyl acetate and water provides some evidence for further consideration.

To verify spot bW as being quinic acid, another dried chromatogram with ethyl acetate fractions of polyphenols was sprayed with bromphenol blue. This spot, after development, was yellow in color, the same as the standard quinic acid spot. This result is shown in Figure 2, the quinic acid spots exhibiting a white background in the photograph. Quinic acid was thus found in both varieties and for each maturity.

To further substantiate the presence of polyphenols, borate impregnated papergrams were employed (18 and 21), using ethyl acetate polyphenolic fractions. The results are shown in Figure 3 and Table 2. From these experiments it seems that all of the spots are compounds that can be complexed by borate. It is to be noted that all the spots have much lower Rf values, Table 2, than when untreated paper was used, Table 1. It may be mentioned that with other concentrations of borate impregnation, additional spots appeared, even though there was an over-all depression in Rf values.

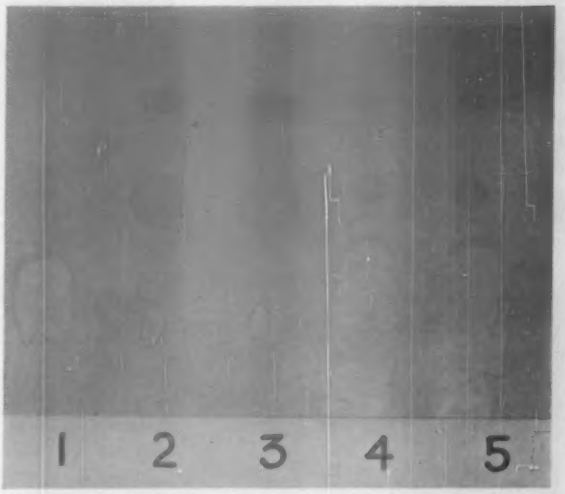

Figure 2. Bromphenol blue sprayed papergrams of polyphenols. 1, quinic acid; 2 and 3, Pontiac and Ontario dilute extracts of peel; 4 and 5, same for concentrated extracts of peel.

TABLE 2

Rf values of the potato polyphenol extracts using borate impregnated paper

Spot No.	Variety		Known component
	Pontiac	Ontario	
			0.06 DOPA 0.09 Chlorogenic Acid
a	0.22	0.20	
b	0.26	0.27	
c	0.30	0.30	0.28 Caffeic Acid
d	0.34	0.35	

This spreading effect might have been due to different variations of borate complexing with the polyphenols, or there may possibly be other polyphenols such as the isomers of chlorogenic acid *(3)*.

A polyphenol oxidase enzyme preparation from potato tissue was sprayed on dried developed polyphenolic chromatograms, chromatograms with known

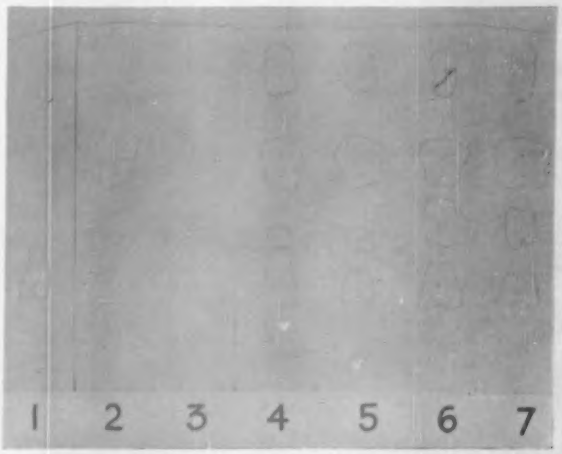

Figure 3. Borate impregnated papergrams of polyphenols. 1, chlorogenic acid; 2, caffeic acid; 3, DOPA; 4 and 5, Pontiac extract of peel, 1st and 2nd harvest; 6 and 7, same for Ontario.

polyphenols, and blank controls, to determine which spots could serve as substrates for the enzyme and be partially responsible for potato blackening. The spots for chlorogenic and caffeic acids on freshly prepared papergrams exhibit a yellow color. It was found that the order of increasing browning was chlorogenic acid, caffeic acid, and DOPA. Spots corresponding to chlorogenic and coffeic acids of both extracts turned brown after the incubation period, as shown in papergrams 4, 5, 6 and 7, Figure 4. Spot b from the Pontiac

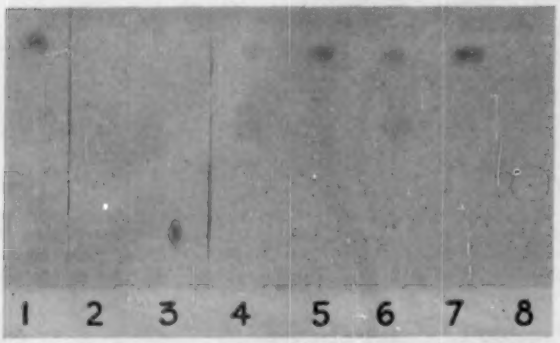

Figure 4. Potato enzyme sprayed papergrams of polyphenols. 1, caffeic acid; 2, chlorogenic acid; 3, DOPA; 4 and 5, Pontiac extract of peel, 1st and 2nd harvest; 6 and 7, same for Ontario; 8, quinic acid.

extract, papergram 5, turned brown also. The browning intensity of these spots was found to be the same as chlorogenic acid and caffeic acid, respectively. The Rf values of the spots were identical also. These data support the view that these polyphenolic substances can serve as precursors to enzymatic darkening and that these compounds, caffeic and chlorogenic acids, are found in both varieties of potato, with an additional unknown compound in the Pontiac variety.

Polyphenolic content at various maturities. The polyphenolic content of two varieties of white potatoes, Pontiac and Ontario, at 3 different levels af maturity, are presented in Table 3. The average values for polyphenolic contents for potatoes harvested 14, 16, and 20 weeks after planting showed the same trend with each of the two assay methods and with respect to degree of maturity. It is interesting that the Ontario variety contains approximately 1.5 times the polyphenolic content of the Pontiac variety. This increase in polyphenols could readily account, in part, for the Ontario potatoes being more susceptible to blackening.

The second harvest, 16 weeks after planting, exhibited the highest polyphenolic content, 19.8 mcg./g. for Pontiac and 32.2 mcg./g. for Ontario (Arnow method), whereas the first harvest, 14 weeks, was found to have the lowest content of polyphenols, 15.2 and 26.4 mcg./g. respectively. The intermediate levels for the third harvest do not appear to be significantly different from the second harvest. Values obtained by the Rosenblatt-Peluso method for polyphenolic content were over twice as high as those obtained by the Arnow method. Both methods give consistent results. The tannin content reported by Cheng and Hanning *(6)* for other varieties of potatoes are approximately 30 times greater than the results reported here for polyphenols. This fact is most likely due to the removal of tannin components during extraction and purification of the polyphenols.

Enzymatic activities. The cytochrome oxidase activity of Pontiac and Ontario varieties of potatoes harvested at three different stages of maturity is shown in Table 4. At all three of the harvest dates the cytochrome oxidase activity of the tubers was higher in the Pontiac than the Ontario potatoes. In both varieties the cytochrome oxidase activity was highest in those tubers harvested 16 weeks after planting, being approximately three times that of tubers harvested after 14 weeks and about twice that of tubers harvested 20 weeks after planting.

TABLE 3

Polyphenolic content of two varieties of potatoes at three stages of maturity

Harvest Weeks after planting	Polyphenolic content, mcg./g. Variety							
	Pontiac				Ontario			
	Arnow method		Rosenblatt-Peluso method		Arnow method		Rosenblatt-Peluso method	
14	11.9 18.4	15.2	29.2 45.6	37.4	25.2 27.5	26.4	54.6 61.0	57.8
16	20.4 19.2	19.8	48.6 48.0	48.3	37.1 27.4	32.2	72.0 63.1	67.5
20	20.6 13.6	17.1	41.4 34.6	38.0	28.4 32.3	30.3	61.6 65.5	63.5

TABLE 4

Enzymatic activity of two varieties of potatoes at three stages of maturity

Harvest Weeks after planting	Activity[1]			
	Cytochrome oxidase		Polyphenol oxidase	
	Pontiac	Ontario	Pontiac	Ontario
	Q_{O_2}[2]	Q_{O_2}	Q_{O_2}	Q_{O_2}
14	1.03	0.84	7.7	10.5
16	3.60	3.07	21.8	19.1
20	2.15	1.72	39.2	47.7

[1] Each value given is the average of four determinations on each of four different extracts. All values have been corrected for endogenous respiration.

[2] Q_{O_2} values are microliters oxygen uptake/hr./mg. dry weight of extract.

Polyphenol oxidase activity of the potatoes in this study is given in Table 4 also. The activity of this enzyme increased with increasing maturity of the tuber for both varieties of potatoes. Except for those potatoes harvested 16 weeks after planting, the polyphenol oxidase activity was higher in the Ontario than in the Pontiac potatoes. These differences were small for the first two harvest dates, but at the third harvest the Ontario potatoes showed approximately 20% higher polyphenol oxidase activity than did the Pontiac potatoes.

This study indicates that polyphenol oxidase activity is higher in the variety of potato which is known to be more susceptible to precoooking discoloration or blackening. It appears that this enzyme may be playing an important role in the discoloration of the tuber.

The finding that the polyphenol oxidase activity increases with increasing maturity of the plant is in

keeping with the proposal of Scudder *(16)* that physiological age may be an important factor in determining the time that potatoes become susceptible to bruising and black spot. He pointed out that tubers are susceptible to black spot only after a certain physiological age has been reached, and that physiological age at harvest time is regulated predominantly by the factors affecting maturity of the plant.

With regard to the results concerning the polyphenolic content and the enzymatic activities of the two varieties of potatoes, it is to be noted that the data were obtained only from one season and one location. Studies involving additional seasons, locations and a greater number of harvests of these and other varieties of potatoes, including storage experiments, will determine to a larger extent the significance of polyphenolic content and enzymatic activity with regard to blackening or discoloration in the white potato.

SUMMARY

Ontario and Pontiac potatoes, representing susceptible and resistant varieties to blackening, were examined qualitatively and quantitatively for polyphenolic content at three levels of maturity; cytochrome oxidase and polyphenol oxidase activities were determined by oxygen uptake measurements.

Using butanol-acetic acid-water (4:1:5) solvent system and ascending paper chromatography five spots were isolated from purified acetone extracts having Rf values of 0.51, 0.58, 0.63, 0.72 and 0.98. There was no qualitative difference between the varieties except for the water soluble red pigment of the Pontiac variety. All of the above substances were repressed by use of 0.1 M. borate impregnated paper which complexes the polyphenols. By use of bromphenol blue spray, quinic acid was shown to be present in the water soluble fraction of both purified extracts.

The polyphenolic content of the two varieties at three levels of maturity was determined by employing the methods of Arnow, and Rosenblatt and Peluso. The second harvest portrayed the highest polyphenolic content for both varieties, and each harvest of Ontario potatoes contained greater amounts of these constituents than the Pontiac variety by a factor of 1.5.

Spraying paper chromatograms with potato enzyme preparations resulted in the browning of two of the Ontario spots and three of the Pontiac spots.

Cytochrome oxidase activity, as determined shortly after harvest, was higher in the Pontiac than in the Ontario variety, being highest in those tubers harvested 16 weeks after planting.

Polyphenol oxidase activity increased with increasing maturity of the potato for both Pontiac and Ontario varieties. This enzyme activity at the third harvest, 20 weeks after planting, was higher in Ontario than in Pontiac potatoes.

Evidence of polyphenolic constituents that are precursors to enzymatic browning and the fact that the Ontario potato has greater concentrations of the polyphenols and polyphenol oxidase may explain to some extent why the Ontario potato is more susceptible to enzymatic blackening than the Pontiac variety.

Acknowledgment

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Some Recent Work on Dehydration in the United Kingdom

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IN A REPORT *(2)* presented to the Institute of Food Technologists in 1954 an outline was given of research in fruit and vegetable dehydration in the United Kingdom. Some of the results of this work, and of work on meat and fish, have been published *(1, 9–16, 18, 21–24, 30-35, 38)* and indicate in part the progress that has been made. In the present article a few of the more recent studies on vegetables and fruit will be mentioned and more consideration will be given to recent work on fish and meat.

PART I. VEGETABLES AND FRUIT

1. **Compression of vegetables.** The dehydration of vegetables achieves considerable reduction in volume, but further reduction (up to about 8-fold) can be obtained by compressing the product, and during the latter part of the 1939-45 war much of the dehydrated cabbage and carrot was produced in the form of blocks. Dehydrated carrot was rendered sufficiently plastic for compression by heating in a stream of air, but cabbage required humidification to about 8% (by injection of steam into the heated air stream) if severe shattering of the tissues was to be avoided. Subsequent prolonged drying of the blocks, with adverse effect on their quality, was necessary, and even then it was impossible to bring the final moisture content of the product to below about 6%.

Recent research has therefore been directed towards preparing a dehydrated cabbage of relatively low moisture content (3-4%), which would become sufficiently plastic when heated not to suffer greatly under compression. The addition of plasticisers [glycerine *(e.g. 4)* or sucrose] gave products with unsatisfactory storage properties, but maintaining a high soluble solids content in the vegetable by reduction of leaching during scalding led to a reduction in fragmentation on compression. In the technique now being employed, the cabbage is scalded in steam before dehydration, or in water containing 1-1.5% of leached-out cabbage solutes (scalding in water is the normal commercial practice in the U. K.). The dehydrated shreds are then heated in a stream of air at 165-170° F. for 1 minute, immediately transferred to a press, the mould and plunger of which are maintained at about 150° F., and subjected to a pressure of 4000 lbs. per sq. inch for 15 seconds. With the machine at present in use the ejected blocks measure approximately 5⅞ in. in diameter and 3 1/64 in. in thickness, and have a density of about 1 g./ml. Subsequent relaxation is very slight, about 1/16 in. in each dimension. No special provision has been made for cooling the blocks, and storage tests at present in progress indicate that there has been no worsening of their resistance to browning under tropical conditions. They have been well received in field trials in the tropics where, after a long journey, they have shown less fragmentation than loose-packed material, and have proved highly acceptable after prolonged storage.

2. **Comparison of steam and water scalding.** Owing to war-time exigencies water scalding was adopted in Britain when the dehydration industry expanded to meet the sudden demands of the armed forces, and there was little opportunity to assess the relative merits, other than on the laboratory scale, of scalding in steam or water. The erection of a full scale steam scalder alongside a rotary water scalder in the Experimental Factory has now allowed direct comparisons of the two scalding techniques on potatoes, carrots and cabbage, and it has been possible to make reasonably accurate assessments of the losses and yields involved and the quality and storage behaviour of the products *(14)*.

Water Scalding. During the processing of carrot strips, 3/16 x 5/16 in. cross section, an increase in the concentration of leached out solutes in the scald liquor from 1% to 4.5% increased the yield of dehydrated product by 30%; when cabbage shreds were being processed an increase in the scald liquor concentration from 1% to 1.5% increased the yield by about 6.5%. In the case of potato, however, the differences are much less. When smaller strips are used losses during scalding are rather higher, but this is due in part to mechanical wastage through the mesh of the drum of the rotary water scalder.

Increase in scalder liquor concentration leads to a reduction in the high temperature storage life of the dehydrated products at 37° C. and compromise levels of solute concentration are advised in practice; these are 1–1.5% for potato and cabbage and about 3.0% for carrot.

Steam Scalding. When the effects of steam scalding were compared with those of water scalding under the conditions of "best practice" (i.e. using the scald liquor concentrations suggested above), the following appeared:

(1) Steam scalding increased the yield of potato by about 7% (mainly due to a reduction in mechanical losses), and there was little or no difference in yield when smaller portions of the vegetables were used. The culinary properties of the steam and water scalded products were similar: the high-temperature storage life of the steam scalded product was rather shorter.

(2) Carrots scalded in steam gave about 3% greater yield, and the product had a rather better flavour, and greater resistance to browning. The latter feature was unexpected; a possible explanation is that during water scalding the vegetable becomes impregnated with scald liquor in which cell solutes have been stewing for prolonged periods—in the normal continuous scalder it takes some hours for the liquor to be completely exchanged. As with potato, reduction in the thickness of the portion of carrot did not lead to increased losses.

(3) Steam scalding resulted in a 12–15% increase in yield of dehydrated cabbage. The colour of the product was slightly less bright, but the flavour was better. Probably for the same reason as was suggested for carrot, steam scalded dehydrated cabbage showed an improvement in storage life at elevated temperatures, especially in retention of ascorbic acid.

3. **Quick cooking dehydrated vegetables.** A number of pre-dehydration techniques have been tried, and the most satisfactory to date has been to scald thin portions in steam for periods which, for different vegetables, vary from 3 to 10 minutes. As with uncooked dehydrated vegetables the rate of reconstitution depends on the minimum dimension of the piece: full reconstitution, for example, takes place in about 4 minutes when pieces 1/16 x 5/16 x 3/8 in. are gently boiled in water, in 8 minutes with pieces of 3/32 x 5/16 x 3/8 in., and in 12 minutes with pieces 1/8 x 5/16 x 3/8 in. The rapid reconstitution of such vegetables appears to make them particularly useful as ingredients in quick-cooking dried soups.

4. **Drying techniques.** Most of the work on hot air drying is done on a three-stage cross flow "tunnel and truck" system, whereas that on vacuum drying is concerned with the "vacuum contact plate" (VCD) method *(2, 15, 28, 23, 24)*. This continues to give highly satisfactory results for a wide range of commodities, and the quality of a number of dehydrated fruit has been improved by modifications of the techniques. A "puffing" technique, in which the vegetable undergoing dehydration is allowed to rise to a temperature of about 80° C. before the vacuum is rapidly applied, has been used to induce a porous structure in certain vegetables. Rapidly reconstituting carrot dice and potato strips ½ x ½ in. in cross section have been prepared in this way. These potato strips can be fried as "French fries" after soaking in hot water for 10–15 minutes.

PART II. DEHYDRATION OF ANIMAL PRODUCTS

1. **Meat products.** (a) *Cooked Meats.* During World War II, techniques were developed for the dehydration of minced cooked meats *(8, 28, 32)* and such dehydrated products were prepared by meat packers in various parts of the world.

In recent years some further work has been done on the dehydration of cooked minces in the U. K. (particularly with reference to the Services' demand for an improved meat bar). Hot air drying was examined in this connection because of the lower capital cost of equipment as compared with vacuum drying.

After preparation of several trial bars the preferred recipe was:

dehydrated minced cooked beef	50 pp.
dehydrated minced cooked pork	50 pp.
salt	¾ pp.
monosodium glutamate	½ pp.
fat content	40%
moisture content	7½%

The bar contains equal amounts of beef and pork fat, a composition which is sufficiently soft to avoid an unpleasant fatty feel in the mouth when the bar is eaten dry. The specified moisture content avoids grittiness in the dry bar and permits compression with a minimum of fragmentation.

Lean pigs, as used initially to minimise wastage in the preparation of the dehydrated pork mince, often gave a product with incipient rancidity. From the work of Callow *(5, 6, 7)*, it appeared that pigs fed according to good practice on a high plane of nutrition should have more stable fat: this proved to be the case. This aspect was further pursued; back fat samples were taken from pigs of three different levels of fatness and examined for iodine values and the relationship between thickness of back fat and iodine value was found to be statistically highly significant.

Addition of an antioxidant during the cooking process prevented rancidity, but the use of antioxidants is not at present permitted by British food laws.

When vacuum contact plate dehydration *(15, 18)* is employed, incipient rancidity does not appear in the product during drying, even when lean pigs are used. It is thought probable, however, that the product from such pigs would be less stable when exposed to air than that from pigs with a greater depth of back fat.

The meat bar is vacuum packed in a triple laminate of MSADT cellophone —0.018 mm. aluminum foil — P4 pliofilm. Storage tests in the tropics show the bar to be palatable after 12 months' exposure, and tests lasting 2 years are in hand. The flavours arising from non-enzymic browning (meat extract) tend at first to enhance the acceptability but the accompanying deterioration in texture is disliked.

Interest in dehydrated cooked meats has been stimulated by demands for "instant" dehydrated precooked meals, which can be made ready to eat within 15 minutes or less. Potentially useful dehydrated precooked minces which satisfy this requirement have been prepared, e.g. beef, ham, chicken and also precooked cubes of beef (approximately ½" edge). A dehydrated macaroni and cheese product has also been prepared. In all cases the vacuum contact plate dehydration equipment is used, the heat input during the first 2 hours being restricted to permit freeze drying.

In the preparation of dehydrated precooked minces cooking the meat as chunks followed by mincing gives a product more easy to reconstitute but also more fragile than the product obtained by cooking after mincing.

(b) *Raw Meats.* For the dehydration of raw meats only the VCD equipment has been considered. The aim is to produce palatable dehydrated meats which readily reconstitute, are stable, and can be cooked in their familiar forms by standard methods.

The earlier dehydrated meat chunks, etc. produced by the VCD technique, were dried as quickly as possible compatible with avoiding heat damage to the tissue *(30)*. The products were somewhat shrivelled, slow to reconstitute (several hours or preferably overnight immersion in cold water), and could be cooked only by "wet" methods. Palatability of the products was inferior to that of fresh meats, but in spite of this they were readily accepted by industrial workers in a canteen. Attempts to speed up reconstitution by pretreatment, e.g. addition of salts or freezing, were fruitless.

Freeze-drying, which is being extensively studied in

U. S. A., can give products which reconstitute quickly. Shrinkage of the tissue does not occur and the light porous product is readily permeated by water.

Attempts to make a similar dehydrated porous meat in the VCD cabinet by "puffing" the superheated tissue with water vapour were unsuccessful, but good results were achieved by slowly freezing the meat, transferring it to the VCD cabinet, freeze drying the outer surfaces and subsequently using the normal VCD process to reduce the drying time *(1, 31)*. With this technique about 90% of the production reconstitutes in 5 minutes or so, though the remainder of the product contains darker areas of shrunken tissue more difficult to reconstitute. The reasons for this are being investigated, and a possible factor is the irregularity in slice thickness: slices with excessively thick areas will have more intimate contact with the heating plates and possibly absorb sufficient heat to produce thawing during the freeze-drying period. Dehydrated raw chops, steaks, and cubed meats have been successfully prepared.

The rate of freezing of the tissue has an important effect on the structure of the dry product, and meat which has been rapidly frozen, e. g. in the drying cabinet by evaporative cooling, failed to give the products which easily reconstitute.

(c) *Storage of Dehydrated Meat Products Prepared by the VCD Process.* Evidence from storage tests with samples packed in nitrogen indicates that the dehydrated raw meats are less stable than the products obtained from cooked meats; e.g. a dehydrated minced cooked beef with moisture/non fatty solids ratio = 0.14 had a shelf life in excess of 28 months at 20° C., and approximately 1 year at 37° C., whereas a sample of dehydrated raw beef with a lower ratio (H_2O/NFS = 0.07) had a shelf life of approximately 4 months at 37° C., with deterioration in flavour and texture probably due to non-enzymic browning. Other contributory factors may be enzymic changes and/or protein denaturation; these aspects are being studied.

As with other dehydrated foods, shelf life can be extended by reducing the moisture content. A taste panel could detect no off flavour in a sample of dehydrated minced cooked pork with H_2O/NFS = 0.023 after 2½ years storage at 20° C.

As has been found in the case of dried egg *(3, 17, 25, 27, 29, 36, 37)* dehydrated minced cooked meats may be improved by removal of glucose by fermentation, or enzymic action *(19, 20, 33, 34)*. Unfortunately, tests have shown that only small quantities of glucose can be removed from raw sliced meats by these techniques, and shelf life of the dry products is unaffected. The efficiency of the process on cooked meats undoubtedly lies in cell rupture and exposure of contents to attack.

(d) *Compression.* Some measure of success has been achieved in the compression of dehydrated raw steaks into cans. With a load of 15 tons (3000 lb./sq. in.) and 10-second dwell, 1 lb. of dry product can be compressed into a 16 oz. flat can. At 40% fat content the compressed steaks can be separated readily; at less than 30% the compressed block is difficult to break down into its component pieces and relaxes more quickly in the open can. The surface fibres of the meat are crushed by compression and their rapid absorption of water enrobes the meat in a gel through which water must subsequently migrate to reach the dry interior: this may explain in part the adverse effect that compression has been found to have on ease of reconstitution of dehydrated raw steaks.

2. **Dehydration of fish products.** Emphasis has been placed on the dehydration of cod, using the vacuum contact plate equipment.

(a) *Dehydration of Raw Fillets.* The VCD equipment was originally designed for the production of "pressfish". In this process cod fillets were soaked in an aqueous solution of potassium carbonate, dried to approximately 15% moisture content, compressed into blocks and then dried further down to 5% moisture. The product was unattractive in colour and flavour, required about 16 hours to reconstitute, and the texture was rubbery, and at times slimy due to the alkali pretreatment (without which the fish would not reconstitute but be dry and fibrous in texture when cooked).

First improvement in quality arose from replacement of the potassium carbonate with sodium bicarbonate. Drying was however, irregular; thin portions of the fish fillet not in contact with both heating plates were incompletely dried during the process. A flat cutting machine was developed to slice cod fillets to a predetermined thickness, and thin areas from tails were built up by overlapping. In this way an even bed of fish was spread on the trays and uniform and intimate plate contact was achieved, but this inhibited egress of moisture vapour from central regions of the tray, and it was difficult to avoid either blowing the wet fish off the tray during the early stages of drying or subsequently stifling the escape of steam, thereby causing damp areas of partially cooked fish in the dried product. This difficulty was avoided by cutting the fillets into 4–5 oz. portions and spreading on the drying trays with channels between them.

It was found that compression and the second drying stage in the "pressfish" process had an adverse effect on texture. These operations were therefore omitted and the cod fillets were dried directly to 4.5% moisture content. By such modifications, and improvements in the drying procedure, a product was obtained which reconstituted in about 2 hours and was reasonably palatable.

Reconstitution of the dehydrated fish could be speeded up by a puffing process (also applied successfully later to certain vegetables) whereby an "open" structure was given to the product by the rapid evolution of water vapour from the superheated fish. The process was difficult to control, some cod fillets being expanded to a rather loosely connected series of fish myotomes useful only for made-up dishes.

Freezing of the raw fish and modifications to the drying procedure have rendered chemical pretreatment unnecessary. Loading the VCD plant with frozen blocks of regular thickness enables its system of parallel heating plates to be used more efficiently. In the present dehydration process the fish blocks are freeze dried for the first 2 hours, after which temperatures are raised to facilitate dehydration as in the case of meat. The

commercial plant is able to reduce the moisture content to 2% in about 10 hours, the product being very porous, equal in bulk to the initial wet material and similar in appearance and properties to freeze dried fish.

(b) *Shelf Life.* At elevated temperatures, shelf life is, as for other dehydrated foods, markedly affected by moisture content. Deterioration of dehydrated fish (packed in nitrogen) is shown by a gradual toughening of the texture, the development of a baked-fish flavour, and a yellow-brown discolouration. At 37° C. the storage life of material of 10–12% moisture content is 2–4 weeks; with moisture content 7%, little more than a month, and at 4–6% moisture content about 2–3 months. At 3% moisture content there was great extension of the storage life and the fish was still edible after a year at 37° C., though appreciable deterioration had occurred. When dehydrated cod, initially of 3% moisture content, was stored at 37° C. with an in-package desiccant, the material showed little change after 15 months (the moisture content at this stage was 0.5–1.0%).

(c) *Dehydrated Precooked Fillets.* When cooked fillets are frozen and dehydrated by a procedure similar to that employed for raw fish, a product is obtained which reconstitutes almost instantaneously, and has an appearance, flavour, and texture very similar to cooked fresh cod.

If the cooked fillets are broken down before drying, e.g. in a dough mixing machine, a product of uniform composition is obtained; this has proved of value in the preparation of diets in hospital metabolic units.

This same material mixed with mashed potato powder and seasonings gives an "instant" fish cake mix. After stirring with sufficient water to produce the correct consistency for moulding, the mixture is immediately ready for frying.

(d) *Dehydrated Shrimps.* Cooked shrimps after shelling and de-veining have been dehydrated by the VCD procedure employing an initial 2-hour period of freeze-drying to give a product which reconstitutes in less than 1 minute in cold water. The texture and flavour of the reconstituted shrimp differed little from the original.

PART III. GENERAL

Future progress may be considered under four broad headings.

1. **Production of more attractive commodities.** Most dehydrated foods have suffered from the necessity for manufacturing them in small portions—flakes, small dice, minces or purées. The experimental production of potato "French fries", carrot and potato slices, steaks, chops, fish fillets etc. is an indication that dehydrated foods will be produced in more familiar and versatile forms.

2. **Production of quick-cooking meals.** There is an obvious value, for both civilian and military use, of quick-cooking dehydrated products. The degree of success so far attained encourages the belief that there will soon be practical results in this field, with possibly even fully pre-cooked meals, requiring only the addition of hot water for reconstitution.

3. **Improvement in storage life of dehydrated foods.** With greater understanding of the factors affecting storage life (especially tropical storage), and with technical advances allowing the application of such knowledge, a steady increase in stability of these foods should be possible.

4. **Reduction in bulk.** Development of the technique for compression of cabbage as a commercial operation should be possible in the near future. Certain other vegetables, for example, carrot and swede (rutabaga) present few problems. By contrast, the satisfactory compression of dehydrated potato seems as remote as ever. The compression of dehydrated raw meats is being examined, with promising results.

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Storage Properties of Gamma-Irradiated Potatoes[a]

(Manuscript received July 24, 1956)

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EARLIER LIMITED STUDIES at The University of Michigan *(3)* and elsewhere *(5)* indicated that low-dosage gamma irradiation of potatoes was useful in preventing sprouting and spoilage of potatoes under storage without the development of undesirable changes. Because of sprouting followed by rapid deterioration, it is usually not possible to keep northern-grown potatoes under storage for more than 8 or 9 months of the year. It is believed that desirable types of potatoes can, by irradiation, be made available the year around. This treatment might be particularly useful in increasing the storage life of any type of potato shipped overseas for the Armed Services. However, little was known about the limitations of the process of irradiation and about the optimum conditions for storage of irradiated potatoes. During the past year a study has been conducted with support from the U. S. Army Quartermaster Corps to explore the storage properties of irradiated potatoes. The gamma irradiations have been performed at the Fission Products Laboratory, Engineering Research Institute, The University of Michigan, and the research studies have been conducted jointly at the University of Michigan and at Michigan State University.

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces and has been Assigned No. 672 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

I. SPRING IRRADIATION AND SUBSEQUENT STORAGE OF IDAHO GROWN RUSSET BURBANK VARIETY (SEED) POTATOES

A. Irradiation

Because of the late date (May, 1955) of activation of this research program relative to the potato season, uniform potatoes of good quality and known history which were suitable for experimental studies were difficult to obtain when the study began. Twenty bags, 100 lb. each, of Idaho certified seed potatoes of the Russet Burbank variety and with known history were obtained.

The potatoes were given a radiation dose of 10,000 rep on or about the first of June, 1955, and were put in storage with control lots of the same potatoes at various temperatures nominally controlled at 35°, 40°, 50°, 55°, and 65° F. and at room temperature (75°–80° F.) at The University of Michigan and Michigan State University. Additional lots of the same potatoes were irradiated with doses of 5,000, 15,000, 50,000, 100,000, and 200,000 rep and all were stored at 45° F. These potatoes were weighed every 2 weeks and checked for sprout development.

Samples of potatoes from each of the different dosage lots were put in storage at Michigan State University at 50° F. (50°–55° F.) and 3 controlled humidities. The constant-humidity cabinets were originally to be held at 70, 80, and 90% relative humidity. However, the equilibrium established after placing the tubers in the cabinets resulted in humidities which varied some-

what and when measured were found to be 66, 74, and 90%. Average value was estimated to be 60, 75, and 90% in one measurement and 55, 75, and 95% in another measurement.

B. Sprouting

A slow but steady sprout growth was noted first on the control potatoes stored at "45" and "40" degrees. The sprouts at "45" degrees at the end of October were from 2 to 6 inches long. Control potatoes stored at "35" degrees at this time had tiny sprouts from 3 to 5 mm. long. All the sprouts which formed on the control potatoes stored at "room temperature" withered and died by October 26 as a result of lack of nutrient and moisture.

None of the irradiated potatoes stored at The University of Michigan or at Michigan State University sprouted, except those which received only 5000 rep. These potatoes were stored at "45" degrees and have developed some very short sprouts (3–5 mm. long), much shorter than the control potatoes which were stored at the same temperature. Samples of the potatoes irradiated to the extent of 10,000 rep were stored at all the temperatures listed and none stored in Michigan developed sprouts. However, some of the 10,000 rep irradiated potatoes shipped to QMC in Chicago did show some limited sprouting.

C. Weight loss

Weight loss of Idaho grown potatoes was determined as a function of radiation dosage, storage temperature, storage humidity, and storage time. Increases in storage temperature of irradiated potatoes resulted in increases in weight loss with time. Increases in the storage temperature of the control potatoes resulted in a rate of weight loss considerably higher than that of the irradiated potatoes, probably because of the higher metabolic rate and greater surface for transpiration presented by the sprouts. Potatoes receiving increasing doses of radiation, but held at one storage temperature, showed a marked decrease of weight loss with increase in radiation dose up to 15,000 rep. Radiation doses of 50,000 rep and higher resulted in the same weight loss for the same storage conditions. It appears that 15,000 rep is essentially as effective as higher doses in checking weight loss.

In storage tests at different humidities, the potatoes lost less weight as the humidity of the air in which they were stored increased. It was also observed that irradiated potatoes lost less weight than nonirradiated potatoes when samples of each were stored at the same relative humidity.

Figure 1 is a plot of weight loss vs. radiation dosage for potatoes stored at 50° F. It shows the general trend observed with these potatoes of the effect of increasing radiation dosage on the reduction of weight loss and an approach to an equilibrium value at about 20,000 rep dosage. Increases of radiation dosage above this level have little additional effect on the inhibition of weight loss.

For the case of Idaho grown potatoes used in the studies the radiation-dependent component of weight

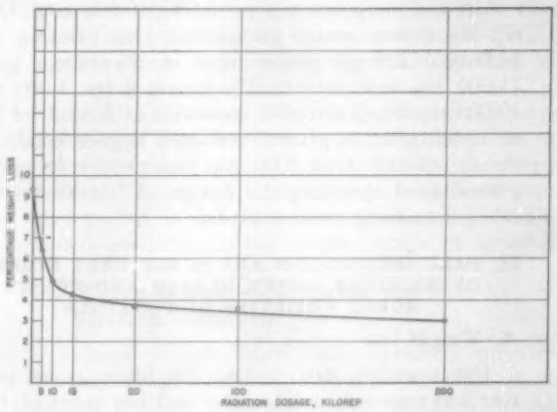

Figure 1. Percentage weight loss of irradiated potatoes as a function of radiation dosage after 58-days storage at 50° F. and 90% relative humidity.

loss demonstrates a logarithmic reduction with radiation dosage. This phenomenon tends to support a hypothesis of weight loss proportional to the number of living cells, if the cells are inactivated by a random, statistical process. Extensive data on a wide variety of unicellular organisms from many laboratories indicate similar exponential radiation inactivation phenomena.

D. Rot and other losses during storage

Table 1 presents the percent of loss attributed to rot and to severe shriveling and lists the percent usable for the various doses used for the Idaho potatoes as of November, 1955. The lots stored at various conditions and which received from 10 to 200 kilorep were considered to be 84.9 to 98.5% usable, whereas none of the controls was usable on November 1. In November, 1955, no sprouts were found on any tubers receiving treatments of 10,000 rep or more, but the total losses of the controls and low-dosage-rate samples resulted in a discontinuation of the major portion of the study of these potatoes and the initiation of a new study.

TABLE 1

Percent loss to rot and severe shriveling, and percent usable at final sampling date (11-1-55) for Idaho potatoes

Relative humidity, percent	Dosage, kilorep	Rot	Severe shriveling	Usable
60 (avg.)	0	1.1	98.9	0
	5	2.1	68.2	29.7
	10	5.0	8.4	86.6
	15	6.8	5.9	87.5
	50	6.4	8.7	84.9
	100	4.6	9.3	86.1
	200	7.4	0	92.6
75 (avg.)	0	0	100	0
	5	0.9	54.5	44.6
	10	1.9	11.0	87.1
	15	2.4	29.2	68.4
	50	2.2	11.1	86.7
	100	3.2	8.2	88.6
	200	4.6	6.7	88.7
90 (avg.)	0	0	100	0
	5	2.5	46.1	41.4
	10	1.5	0	98.5
	15	0	5.5	94.5
	50	3.4	1.4	95.2
	100	2.3	7.1	90.6
	200	5.2	0	94.8

A few of the potatoes given 5,000, 10,000 and 15,000 rep doses were stored for another year. During this additional storage period most of the tubers given 15,000 rep dose rotted. The tubers given 5,000 and 10,000 rep doses shriveled somewhat as a result of loss of moisture but in general remained in good condition. As the tubers given 5000 rep had previously undergone limited sprouting the dosage of 10,000 rep was selected as being most desirable.

II. FALL IRRADIATION AND SUBSEQUENT STORAGE OF MICHIGAN GROWN SEBAGO AND RUSSET RURAL VARIETIES OF POTATOES

A. Weight loss

The procedure described for the Idaho grown potatoes was repeated in November and December of 1955 for Michigan grown Sebago and Russet Rural varieties of potatoes of known history. Weight-loss data for Sebago variety potatoes clearly indicate that, over the range studied, weight loss in this case is an *increasing* function of dosage. Comparing these data with those for Russet Burbank variety Idaho seed potatoes indicates that a marked difference exists in the responses of the two lots of potatoes exposed to radiation treatment. Similar data for Russet Rurals indicate a response intermediate between the other two varieties and show no gross dependence of weight loss on radiation dosage. In addition to differences in variety and source it should be pointed out that the Idaho Russet Burbank variety seed potatoes were irradiated in May after storage for several months, whereas the Sebago and Russet Rural varieties were irradiated after harvest in the early winter of 1955.

These differences among the 3 varieties with regard to weight loss during storage as influenced by radiation dosage are exemplified by typical data in Figure 2. More detailed evaluation of these differences as functions of storage time, temperature, and humidity could be undertaken from the data. It is clear, however, that three qualitatively distinct gross radiation responses are present in the 3 varieties. In all 3 cases, anomalous behavior is exhibited in the dose region less than 20,000 rep. More detailed data in this region might prove enlightening.

The hypothesis of radiation destruction of living organisms, assumed to explain the apparent reduction of metabolism with radiation dose in the Idaho seed potatoes, is clearly not a satisfactory explanation for the phenomena observed in the other 2 varieties. If a second hypothetical process of *radiation-induced* weight loss is proposed, a satisfactory model for the three responses can be constructed. Physiological differences among the three varieties must then be considered to explain the fact that one process is predominant in the Idaho seed potatoes, the other in Sebagos, and neither in Russet Rurals.

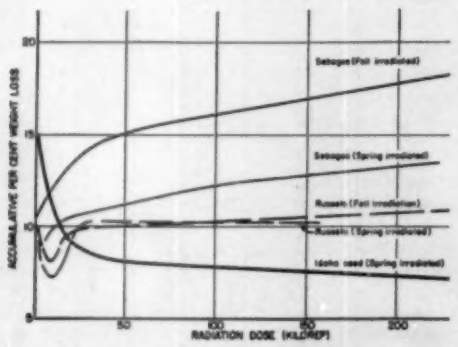

Figure 2. Comparison of typical data for three varieties of potatoes (percentage weight loss vs. radiation dose).

The second hypothesized process might be simply a mechanical damage to intercellular structure, facilitating moisture removal. Given a variety particularly sensitive to such destruction, such a process could conceivably overbalance the reduced metabolism due to radiation damage and produce a gross increase in weight loss with dose.

B. Storage of ring-rot-infected potatoes following gamma irradiation

Field-infected Sebago potatoes were obtained on December 5, 1955, from a grower near Howard City, Michigan, and were gamma irradiated in the Fission Products Laboratory on December 12–13. They were stored at 1° C. and 20° C. at Michigan State University and were first examined on December 22, 10 days after treatment, for incidence of ring rot and other storage rots. Results of this and subsequent inspections on incidence of ring rot for tubers stored at 20° C. are plotted in Figure 3. No trend was observed in incidence of ring rot in tubers stored at 1° C.; therefore, these data were not plotted. In the inspection, tubers suspected of being rotted were cut and those showing typical ring-rot symptoms were considered to have ring rot. Stain diagnosis was not made. Other rotted tubers lacking ring-rot symptoms were placed in a second grouping classed as "storage rot" as plotted in Figure 4.

It should be pointed out that some of the potatoes infected with ring rot in this lot had been discarded during harvesting operations and in grading operations before shipment. Thus, the amount of ring rot shown in Figure 3 does not reflect the total amount of infection in the lot. There was no late blight in the shipment of tubers, which made possible rather accurate diagnosis of the tuber injury.

Tuber injury as a result of irradiation was not evident following 10 days in storage. By the end of 30 days, the majority of tubers receiving 500,000 rep were rotted and a few receiving 200,000 rep had broken down. Positive diagnosis of ring rot in tubers receiving the 500,000 rep treatment could not be made due to inability to identify ring rot following severe radiation injury.

Radiation injury resembled severe freezing injury in many respects. Affected tubers were often somewhat cheesy in consistency, later breaking down into a soft rot. Affected tubers often had a fermented odor, and the general appearance was more suggestive of storage rots of the sweet potato than that of the Irish potato. The alcoholic-type fermentation observed in the tubers receiving the higher dose of gamma radiation may have

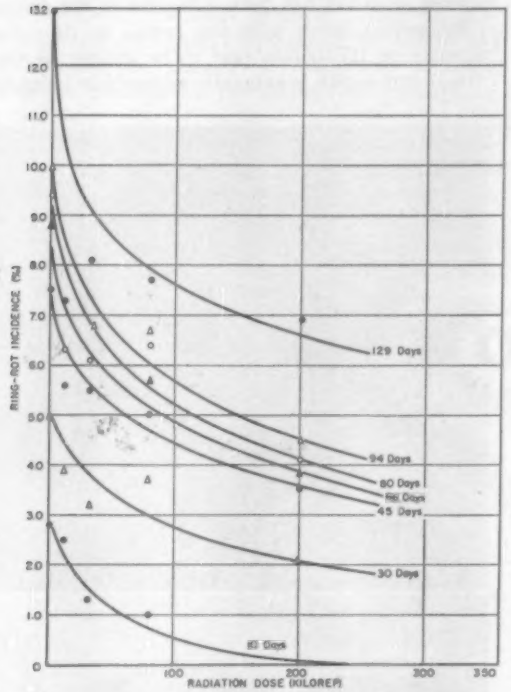

Figure 3. Ring-rot incidence in irradiated field-infected Sebago potatoes stored at 20° C.

some connection with the sucrose analyses reported later.

Many tubers held at 20° C. were rather badly wilted after 80 days in storage. Nonirradiated controls were so badly sprouted at the 129-day inspection that all tubers were cut for ring-rot evaluation. At 1° C. storage there was little wilting after 133 days and tubers had not begun to sprout.

At 20° C. storage (Figure 3) there was some evidence that ring rot was developing somewhat more slowly in the irradiated tubers than in the untreated tubers. The increase in incidence of ring rot at the 129-day period is due in part to the cutting of all the tubers remaining in the sample because of sprouting.

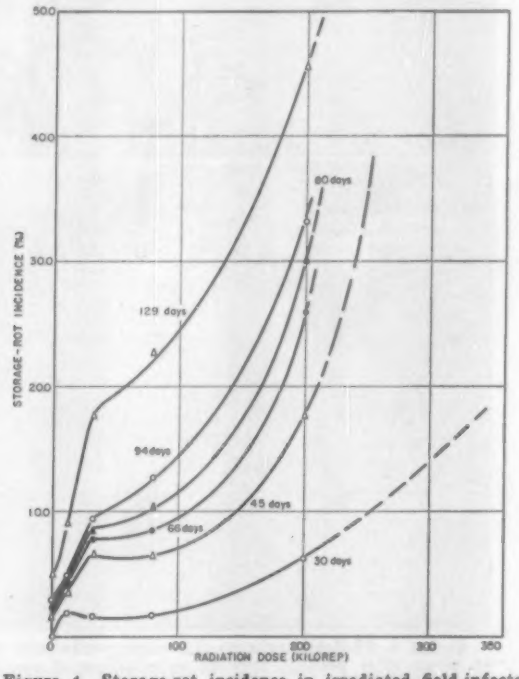

Figure 4. Storage-rot incidence in irradiated field-infected Sebago potatoes stored at 20° C.

C. Wound healing, suberization, and periderm formation

Sebago, Russet Rural, and Katahdin varieties of potatoes were irradiated and then wounded to study wound healing, suberization, and periderm formation. In an initial study, suberization and periderm formation following wounding of nonirradiated Sebago tubers were observed. These tubers were peeled uniformly by hand, packed loosely in moist sphagnum moss, and held at 26° C. for the 2-day period during which observations were made. A half-inch cork borer was used to obtain tissue samples which were taken from the median region of the tubers. The cylindrical samples were then trimmed to rectangular shape, fixed in FAA, dehydrated in an ethyl alcohol series, changed to chloroform, infiltrated with and embedded in ordinary paraffin, and cut into sections 10 to 20 μ thick on a rotary microtome. The sections were stained with safranin and fast green. This procedure was standard for all material prepared for this study.

Preliminary study of untreated Sebago tubers yielded results similar to those described by Artschwager *(1)* in his classical study of potato histology. Six hours after wounding there was evidence of suberization of the surface layer of cells. This layer increased in depth and in density of suberin deposit until after 48 hours 3 to 4 cells from the wounded surface showed distinct suberization. Periderm formation was not evident after 36 hours, but after 48 hours distinct periderm involving 2 to 4 cells was apparent. Some of these cells appeared not to have completed division, but were binucleate with traces of developing wall appearing along a median plane of the parent cell.

In the second series of tests, Sebago tubers which were irradiated at 0–, 15, and 200–kilorep dosages and stored for 50 days were then peeled and sampled as described for the initial study, but the number of sampling intervals was increased to include 0, 6, 12, 24, 48, 96, and 192 hours after wounding.

At 6 hours after wounding only the nonirradiated tubers showed any suberization. Traces of suberization were apparent in treated sections after 36 hours, and at 48 hours there was little to distinguish the suberization in treated sections from that in control sections. Periderm formation in controls was not evident at 48 hours, but periderm was well developed after 96 hours. There was no evidence of periderm formation in either of the two treated series even after 196 hours, and it is assumed that cell division was completely inhibited in the treated potatoes, precluding the possibility of periderm formation. Beginning at the 48-hour stage and

continuing through 96 and 192 hours, the depth of the layer of suberized cells and the intensity of suberization were essentially the same in both treated and control potatoes. Figure 5 illustrates the response of tubers at each treatment level subsequent to wounding.

In the third series, tubers of Sebago, Katahdin, and Russet Rural varieties were irradiated at 0, 2500, 5000, 10,000, and 20,000 rep dosages and were wounded (peeled) 8 days after treatment. These tubers were sampled after 36, 72 and 192 hours. Suberization occurred in all tubers with little difference evident among the various treatments and varieties. Irradiation at any level prevented formation of any distinct periderm, although in at least one sample of Katahdin treated at 2500 rep some periderm-like cells could be distinguished.

In a fourth series, 29 days elapsed between irradiation and wounding. In other respects this experiment was similar to the preceding test. In Sebago tubers, no distinct periderm could be distinguished in tubers receiving any level of irradiation. At 10,000 rep there were scattered periderm-like groups of cells and other treated tubers showed occasional pairs of periderm-like cells. Distinct periderm was evident in controls after 72 hours. Suberization was delayed but not prevented by the irradiation treatments.

Katahdin tubers showed evidence of slightly more frequent periderm-like divisions, but again there was no obvious continuous periderm such as appeared in control tubers. Suberization was delayed slightly less than in Sebago tubers.

Russet Rural showed fewer of the scattered periderm-like areas than either Sebago or Katahdin. These were observed chiefly in tubers irradiated at 2500 rep, but not at higher dosages. However, suberization was not very distinctly slowed in Russet Rural, in contrast to the other 2 varieties.

D. Studies on potato ' hormones''

The observation that plants tend to grow toward the source of light is very old. That this phototropic action is related to definite chemical compounds was first clearly indicated in the classical investigations of Boysen-Jensen *(2)* on the coleoptile of Avena. Naturally occurring chemical compounds possessing the property of being able to regulate plant growth were given the name "hormone". Any compound, either synthetic or naturally occurring, that has this property is termed auxin. A large number of scientific articles have appeared relating to auxins *(4)*.

In general, if no auxin is present, there will be no growth, but a supra-optimal concentration of auxin will also prevent growth. Only minimal quantities are required for plant growth, and the application of an excess will retard or stop growth. By the use of chemicals it is possible to prolong artificially the rest period of potato tubers. On the other hand, the normal resting period can also be shortened by using ethylene chlorohydrin. The belief prevails that auxin content not only varies in quantity during storage, but that the concentration also varies in the different parts of the potato. Prior to sprouting of the potatoes in the spring an increase in auxin has been observed in the fleshy part of the potato, while later the auxin, or its precursor, increases in the potato peel. The change of the precursors into auxin is generally assumed to be enzymatic

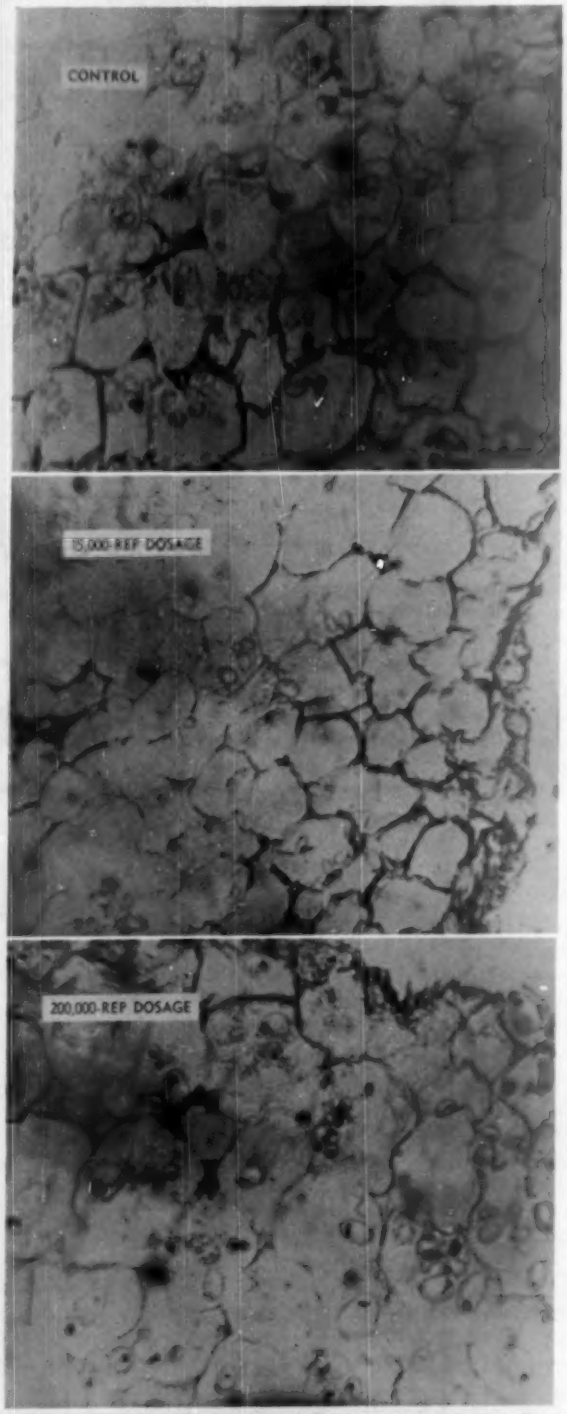

Figure 5. Photomicrographs of Sebago potato-tuber sections 48 hours after peeling, showing suberization of control and treated tubers. Initiation of periderm is evident in control only. 30 ×

in origin. One of the chief precursors may be presumed to be the amino acid tryptophane, because it has been shown that the amount of biosynthesis of auxin in a medium depends on the content of tryptophane in the medium.

One objective of this research project was to increase the storage life of potatoes as a result of gamma irradiation. Gamma irradiation has been shown to slow down or halt sprouting. Therefore, a study of the concentration of the growth-regulating substances which control sprouting was considered advisable. This study involved a comparison of concentrations of phytohormones in irradiated and nonirradiated potatoes under varying storage conditions.

In this research study an extract of the "eyes" and a small amount of surrounding tissue of potatoes was made with freshly distilled ether which is completely free of hormone-destroying hydrogen peroxide. The various growth-regulating substances were then separated by paper chromatography.

The sample consisted of the eyes of several potatoes, including a small portion of the flesh around each eye. Eyes at the apical end were not used because they seemed quite variable. About 10 g. of this material was collected and covered with peroxide-free ether. Ether and eye tissue were kept in the refrigerator (about 40° F.) for a period of 20 hours. The ether was then decanted and evaporated to dryness. The residue was taken up in about 0.1 ml. of alcohol, and this solution subjected to paper chromatography.

The auxins separated by chromatography were assayed by the Avena (oat) technique. In this procedure 72-hour-old plants which had been grown in the dark at a relative humidity of 85% and at a temperature of 25°–26° C. were used. Plants of this age and grown under these conditions are very reactive. This assay procedure was originally developed by Went *(6)*, but it has been variously modified by other investigators.

A preliminary set of experiments was conducted to test the Avena assay with varying amounts of whole extract (not chromatographed) of the eyes of nonirradiated tubers, using Sebago variety potatoes. Results showed that such extracts had pronounced growth-hormone activity. A second set of experiments was conducted with Sebago variety potatoes to determine if the extract could be resolved by paper chromatography into separate components, and to determine the activity of each. In the early studies, 2 components were separated, one which moved slowly, by paper chromatography, and one which moved fast. The latter was found to consist of essentially all the growth-promoting activity of the original mixture (Positive bending of the oat coleoptile to an approximate angle of 25°). The former, however, appeared to possess slight growth-hormone-inhibiting activity, as shown by a negative bending of the oat coleoptile. The extent of the negative bending was considerably less than 25°, indicating that the hormone inhibition, if any, was considerably weaker than the positive growth-stimulating activity. Furthermore, the subsequent assays showed no evidence at all of the hormone-inhibitor activity in the eyes of nonirradiated as well as irradiated potatoes. This would be consistent with other studies which have shown the amount of growth-hormone inhibitor to decrease with cessation of dormancy.

Another set of experiments was conducted to determine the effect of irradiation of the potatoes on the hormone activity of the eye tissue directly after irradiation. Sebagos given 5, 15, 25, and 50 kilorep were used in the first assay. It was found that all doses of radiation caused a decrease in growth-hormone activity. As mentioned, there was no hormone-inhibition action in either irradiated or nonirradiated samples. Most of the activity appeared to come from one "spot" on the paper chromatogram, although this region of the chromatogram may contain several components only partially resolved. It was not possible to distinguish differences in the extent by which different doses of radiation caused a decrease in hormone activity with respect to controls. In a set of experiments with Russet Rurals given 5-, 15-, and 25-kilorep dosages of radiation, similar results were obtained. Since samples of Sebagos and Russets have not yet been assayed in the same experiment, it is not possible to compare the two varieties.

It was also noted that throughout the course of these experiments, the amount of growth-hormone activity in the control (nonirradiated) Sebagos, which were used each time an experiment was conducted, had been slowly but steadily decreasing. Whereas the approximate average angle of bending was 25° in the first experiments, it decreased to 18° in experiments conducted 2½ months later.

When the hormone and inhibitor concentrations of the control and irradiated Sebago tubers were compared, it was found that the observed differences were of such a small magnitude that they could be the result of errors in technic and not due to any significant difference between irradiated and control tubers. This indicates that the inhibition of sprouting as a result of irradiation is not associated with the hormones and inhibitors found in or just around the eyes in Sebago variety stored potatoes.

In late March a shipment of freshly harvested Pontiac potatoes was received from Homestead, Florida. These potatoes were obtained for the purpose of investigating the hormone and inhibitor concentrations in freshly harvested tubers.

Three experiments were conducted with the Pontiac tubers. The first test was made for the purpose of determining what amounts to use in subsequent experiments. In the other 2 tests, dosages of 25 and 75 kilorep were given a week before the analyses. Table 2 gives the results for the 2 experiments.

TABLE 2

Hormone activity of Pontiac variety potatoes

Date	Treatment	Total hormone activity in degrees curvature of oat seedlings	Total inhibitor activity in degrees curvature of oat seedlings
April 13	Control	10.0	1.9
	25-kilorep dosage	17.6	0
April 20	Control	9.2	22.8
	75-kilorep dosage	13.5	16.2

These 2 experiments would tend to show that irradiation increases the hormone concentrations. In the April 20 experiment there is for the first time evidence of a high concentration of inhibitor. This was found both in the control and the treated tubers so there seems to be no error. In both experiments treated tubers had less inhibitor.

Results listed in Table 2 indicate that sprout inhibition as a result of irradiation is not caused by a decrease in activity of the growth hormones or an increase in the amount of growth inhibitor. In fact, these results indicate the exact reverse—an increase in growth hormone and a decrease in inhibitor. Additional data will be required to establish this point. However, these results support some earlier studies made with irradiated pearl onions and irradiated seed black walnuts. In both of these cases low doses of radiation from 10,000 to 50,000 rep actually stimulated the sprouting of the irradiated onions and walnuts prior to the sprouting of the controls. But these sprouts were short lived and died after reaching a length of about ½ inch, whereas the controls subsequently sprouted and the sprouts continued to grow. These limited observations support the idea that growth hormones may be increased and/or growth-hormone inhibitors decreased as a result of gamma irradiation.

The studies on periderm formation (see Figure 5) indicate that cell division is inhibited by gamma irradiation. This also checks with general observations of the effect of low doses of gamma radiation on microorganisms. At the time of irradiation there is little observable effect on the microorganisms, and some time must elapse before the effects of irradiation become apparent. Most cells continue to respire normally after irradiation and to show other biological characteristics such as motility where it occurs normally. However, the irradiation appears to interfere with the process of cell division. Some individual cells may grow to giant size before dividing and when cell division does occur, the daughter cells do not redivide.

The hypothesis is proposed that sprout inhibition in irradiated potatoes is caused by a mechanism induced by irradiation which interferes with cell division. The production of growth hormones may be stimulated as a response to the damage to the cells caused by irradiation.

SUMMARY AND CONCLUSIONS

The optimum effect of gamma irradiation in increasing the storage life of potatoes was obtained with Russet Burbank variety potatoes irradiated in late spring. Irradiation in the spring appears to be preferable to irradiation in the fall or early winter. Russet Burbank and Russet Rural varieties of potatoes appear to have better storage properties after irradiation than does the Sebago (a white skin) variety.

The optimum radiation dose appears to be about 10,000 rep. The optimum storage conditions appear to be about 45° F. and about 85%–90% relative humidity.

In the studies on Russet Burbank variety tubers, weight loss for a given storage decreased with increased dosage up to 15,000 to 25,000 rep, whereas the reverse effect was observed with the Sebago variety tubers. Length of storage prior to irradiation as well as variety may have caused these differences.

In studies in suberization and periderm formation, all levels of gamma radiation tested (15,000 to 200,000 rep) were found to inhibit periderm formation completely and to delay but not inhibit suberization.

Hormone studies on Sebago variety irradiated and control potatoes stored for some time showed such low hormone content that no effect or irradiation could be detected. However, limited data on freshly harvested Pontiac variety (Florida grown) tubers indicate that gamma radiation increases the hormone concentration and decreases inhibitor concentration.

Studies on field-infected Sebago variety potatoes indicate that gamma radiation decreases incidence of ring rot on potatoes stored at 20°C. but has no significant effect on the same tubers stored at 1° C. However, other unclassified forms of rot increased at both storage temperature with increases in radiation dosage.

Respiration studies on potato-tissue slices show no significant effect of gamma-radiation doses of 5,000, 10,000, and 15,000 rep. Doses of 50,000, 100,000, and 200,000 rep resulted in higher respiration rates for the slices of irradiated tubers as compared to the control. This has continued with time of storage.

Respiration studies on whole tubers gave results similar to the tests on slices for doses of 50,000, 100.000, and 200,000 rep. Low doses of 5,000, 15,000, and 25,000 rep show (as compared to controls) a drop of about —30% in respiration rate during the first day after irradiation, followed by a sharp increase the second day to about plus 60%, followed by a gradual decline to about—5% at the 13th week of storage.

Carbohydrate analyses for reducing sugar, sucrose, and starch show little effect of low radiation dose or length of storage on these analyses. Higher radiation dosages and lower storage temperature increase the sucrose concentration.

Studies on enzyme systems have shown a sharp reduction in reduced ascorbic acid content at radiation doses of 10,000 rep and an additional but more gradual reduction at higher doses.

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Maturation Changes in Tomato Fruits Induced by Ionizing Radiations[a, b]

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LOW LEVELS OF RADIATION appear to have the most promising immediate application in the food field. Doses below the sterilizing amount of 2.0 x 10^6 rep are effective in many respects and deleterious effects of irradiation upon the food are minimized *(1, 5)*. Gomberg, Gould, and Bethel *(2)* have shown that with a maturation-inhibiting radiation dose of 15,000 rep the trichina larval cycle in pork could be broken. By the same token insect infestation of cereal products can be conveniently controlled by doses of less than 100,000 rep *(7)*. The extension of shelf life of prepackaged meats may be extended five-fold by low levels of radiation of the order of 50,000 rep *(11)*. The sprouting of potatoes has been found to be inhibited by 10,000 rep and the storage life extended to periods in excess of one year *(12)*. As pointed out by Hannan *(4)*, the interesting possibility of interfering with the metabolism of living plant products has received little attention. It was deemed significant to observe the effects of ionizing radiations upon respiratory activities and pigment biogenesis of fruits of *Lycopersicon esculentum*, the common tomato.

The normal respiratory pattern for ripening tomatoes has been described by Workman *(13)* to increase from a pre-climacteric low rate of carbon dioxide evolution at the mature green-ripe stage to a climacteric at the point of first red color development, followed by decreasing rates through the light pink and the dark pink stages, and reaching a rate comparable to the pre-climacteric low at the table ripe and canning ripe stages.

The color of mature tomatoes results from the presence of yellow carotenoid pigments and the red pigment, lycopene. Their distribution in the pericarp and the proportionate amounts of each pigment determine the variation in shade and intensity of color *(3, 6)*. Hannan *(4)* has reported that mature tomatoes exposed to 20 x 10^6 rep show little immediate change except some loss of texture and flavor and a slight bleaching of color. Proctor, Lockhart, Nickerson, and Goldblith *(9)* observed no textural loss and only a slight bleaching of concentrated tomato juice at 250,000 rep. Proctor, Goldblith, and Nickerson *(8)* in observing the effects of low level treatments of 200,000, 300,000, and 400,000 rep at 2 m.e.v. and subsequent storage on the acceptability of tomato fruits, reported that irradiated pink and full red samples were more acceptable than non-irradiated controls. They also observed these dosages to exert no effect on the ripening properties of green tomatoes.

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[b] Purdue University, Agricultural Experiment Station, Journal Paper No. 1063.

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EXPERIMENTAL

Irradiation was accomplished by means of 4.5 m.e.v. cathode ray produced by a linear electron accelerator. Changes in the respiratory behavior, surface color development, and pigment biogenesis were determined.

Fruits. Tomatoes used in these experiments were the variety Tippecanoe and a cross designated as 6-1205-17 x Sunray. Both produce normal red fruit of rather uniform size and globular shape. Groups of fruit in any one set of observations were of the same variety and originated from the same growing plot. They were selected at the mature green stage, about 2⅛ inches in diameter, inspected for freedom from defects, and removed to constant temperature and humidity storage of 70° F. and 65% relative humidity.

Respiration measurements. A Liston-Decker type, infra-red gas analyzer was employed for these observations. Individual fruits were placed in a 70° F. constant temperature chamber during the period of measurement and rates of respiration, based upon mg. CO_2 evolved per hour per 100 g. of fruit, were determined. Fruits were assigned to treatment on the basis of respiration and, each group contained fruits with respiratory activities similar to the other groups. The effects of various dose levels (0.5 x 10^6, 1.0 x 10^6, and 1.5 x 10^6, and no treatment) immediately and at intervals of 24, 96, 172 and 268 hours were determined.

Effects on surface color development. Devleopment of surface color was objectively measured by means of the Hunter Color and Color Difference Meter employing the tomato red standard. Equivalent assignment of fruits to treatment initially was also accomplished on this basis.

The levels of treatment were 0.5 x 10^6, 1.0 x 10^6, and 1.5 x 10^6 rep, plus the unirradiated control groups.

Changes in pigment content. The effect of high energy electron radiation on the actual pigment content of tomatoes at intervals following exposure was determined, utilizing the chromatographic and spectrophotometric method of Zscheille and Porter *(14)* as modified by Rabourn *(10)*. The individual pigments assayed were beta carotene, phytofluene, gamma carotene, and lycopene. In order to eliminate variation in ripening properties between fruits, the specimens were halved and mounted on paraffin for treatment and storage. In this manner it was possible to compare halves of the same fruit as treated and control entities. The treatment applied was 0.5 x 10^6 rep. Hunter a/b surface color values were taken to give pattern to the sequence of fruit sacrifice for pigment extraction. At intervals after treatment the untreated halves having the higher a/b (red to yellow) ratio were selected with the corresponding treated halves for pigment studies. The net result after a 2-week period was a sequence of pigment extractions on fruits ranging from the breaking pink to red-ripe stage of coloration.

RESULTS

Changes in respiration. The respiratory activities of tomato fruits exposed to 0.5, 1.0, and 1.5 x 10^6 rep, respectively, are indicated graphically in Figure 1 along with similar observations on normal-maturing, unirradiated fruit. The untreated normal control curve illustrates that as the fruits mature, respiration gradually increases from a pre-climacteric low, to a climacteric, and then decreases gradually as the fruit becomes fully mature, which is in agreement with the findings of Workman *(13)*. In contrast, with the treated fruits an initial increase in carbon dioxide evolu-

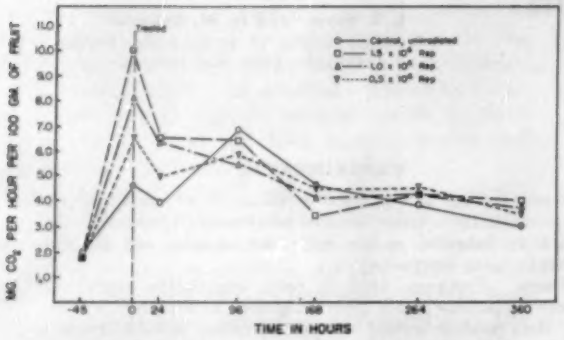

Figure 1. Respiration values of tomato fruits irradiated at three-dose levels.

tion is indicated in direct proportion to the dose supplied. This hypothesis was tested by calculating a regression line for respiration and dose and fitting the respiratory values observed immediately after irradiation to this line. Results presented in Figure 2 illustrate the linear relationship between treatment and resulting rate of respiration. This immediate effect persisted for about 96 hours as determined by the statistical analyses summarized in Table 1. After this time, there was little evidence of a difference in respiration between the irradiated and control fruits.

Effects on surface color development. The effects of three dose-levels of high energy electrons upon the surface color development of mature green ripe tomato fruits are presented in graphic form in Figure 3. The average color readings illustrate the effect of ionizing radiations on subsequent color production.

It should be noted that in each case the resultant end-effect is a slight reduction of red color development in the treated fruits at each level. This would indicate the color-development mechanism has been interfered

TABLE 1

Statistical evidence of respiration differences between treatments with time

Time after treatment	Calculated F*	Required F**	
		5% level	1% level
Hours			
0	21.42	3.01	4.72
24	16.10	3.01	4.72
96	2.98	3.01	4.72
168	2.45	3.01	4.72

* Statistical value for differences between treatments.
** Value necessary for significance.

with. Curiously, an increase in red pigment production is shown for a time at the highest level (1.5×10^6 rep) of treatment. This might be explained by drawing a corollary to the stimulatory effect previously found for respiratory activities. That is, at this high level, the substrates utilized in the production of red color are rendered more available to the enzymatic processes involved; whereas, this does not occur at the lower dose levels in that the threshold of ionization phenomena has not been reached to allow such a stimulation to be functional.

The patterns shown in Figure 3 do show a final inhibition of red color production in tomato fruits exposed to cathode ray irradiation.

Changes in pigment content. The pigment assay data for extraction of treated and untreated fruit halves at various time intervals are shown in Table 2 and the net effect on pigment development is presented graphically in Figure 4.

Statistical evaluation of the influence of treatment, fruit maturity, and the interaction of treatment and fruit maturity, upon the pigment content of fruit-halves receiving 0.5×10^6 rep as compared to their unirradiated halves is presented in Table 3.

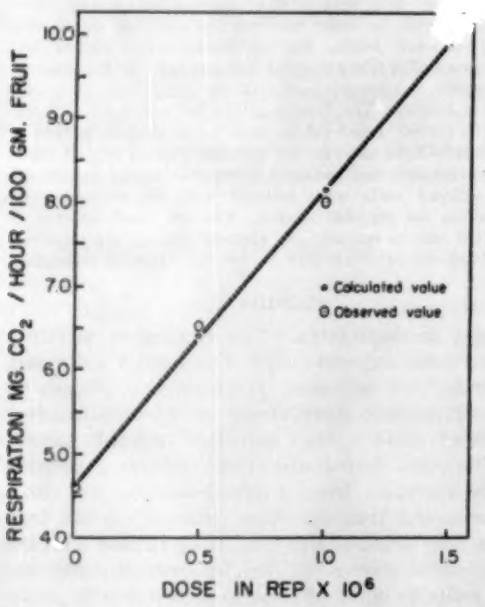

Figure 2. Regression of treatment levels on resultant respiration of tomato fruits.

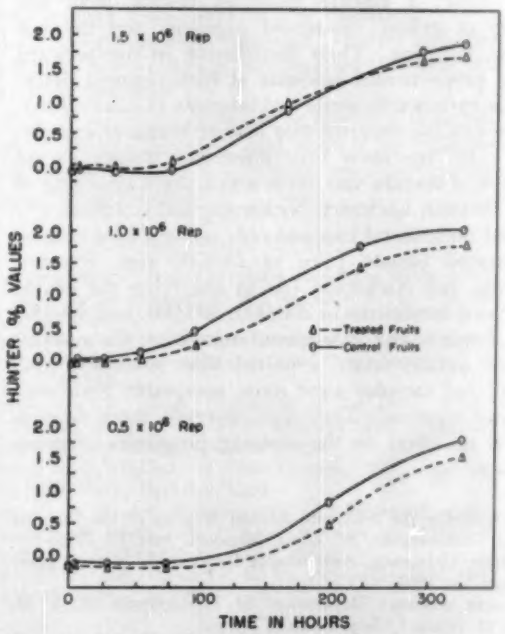

Figure 3. Effects of irradiation on color development of tomato fruits.

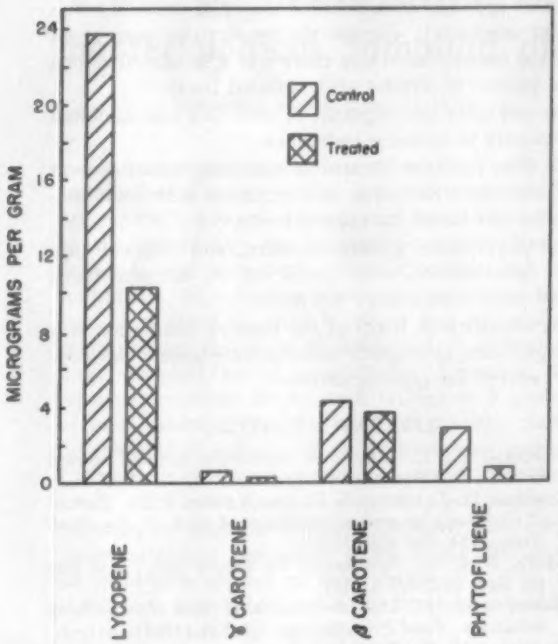

Figure 4. Effect of irradiation of 0.5 × 10^6 rep on total individual pigment development of tomato fruits.

The evidence demonstrates a highly significant inhibitory effect of ionizing radiations upon phytofluene, gamma carotene, and lycopene pigment content of ripening fruits; whereas the beta carotene levels appear to be unaffected. Examination of the original data (Table 2) reveals that the beta carotene content remains relatively unchanged for both treated and control samples, which would indicate that the amount of this pigment present is unaffected by irradiation and that its level does not change, apparently, during the development of red color in the tomato fruit. Fruit maturity or age of fruit at time of treatment is a significant variable only in the case of gamma carotene; or, in other words, the level of content of this pigment appears to be unrelated to the stage of fruit ripeness. The effect of irradiation at slightly different levels of maturity is demonstrated by the interaction of treatment and fruit maturity. Again, the only real evidence

TABLE 2

Surface color and pigment development in unirradiated fruit halves and corresponding halves receiving 0.5 × 10^6 rep

Time hours After treatment	Average Hunter a/b values		Phytofluene		Beta Carotene		Gamma Carotene		Lycopene	
			μg./g.		μg./g.		μg./g.		μg./g.	
	T	C	T	C	T	C	T	C	T	C
3	0.363	0.359	0.39	0.38	2.91	3.45	0.16	0.19	2.99	3.45
24	0.390	0.595	1.03	1.97	2.35	3.32	0.10	0.34	8.25	13.05
48	0.366	0.823	1.69	2.46	4.08	4.47	0.59	0.91	16.99	23.10
72	0.306	0.994	1.61	3.97	5.65	4.27	0.31	1.95	12.76	25.75
120	0.230	1.224	0.45	3.03	4.74	3.83	0.41	0.71	18.25	33.00
168	0.286	1.152	1.39	2.88	2.77	1.70	0.26	0.22	18.23	26.58
216	0.242	1.640	0.40	3.62	7.60	6.36	0.10	0.59	4.18	38.00
288	0.371	1.763	0.33	5.01	3.87	4.04	0.26	0.47	6.25	37.76

(T) Treated half.
(C) Control half.

TABLE 3

Statistical significance of irradiation upon pigment development

Source of variation	Phytofluene	Calculated F values		Lycopene	F value for significance	
		Beta Carotene	Gamma Carotene		5% level	1% level
Treatment (T)	13.09	.57	106.67	27.99	4.96	10.04
Fruit Maturity (M)	1.23	2.49	43.33	2.64	3.14	5.21
Interaction M x T	1.15	.29	25.00	1.00	3.14	5.21

is in regard to gamma carotene which is as expected if content of this pigment is not related to maturity.

DISCUSSION

Effects of cathode rays on the respiratory activities, surface color development, and pigment biogenesis, of tomatoes indicate that the normal maturation processes are interfered with. The patterns of interference are different in that respiration increases immediately proportional to the dose applied but the effect lessens with time. The effect on color and pigment development is of a permanent nature, from which the fruits do not recover.

Effect on respiration. Cathode rays produced changes in the fruit which resulted in an immediate increase in respiratory activities directly proportional to the dose applied. The effect was shown to persist at a significant level for about 96 hours at the end of which time no statistical difference could be demonstrated between the rates of carbon dioxide evolved between groups of fruits which had received varying dosages of ionizing radiations.

Of particular interest was the effect produced at the lower dose level of 0.5 x 10^6 rep as compared to higher dosages. The proportional, radiation-induced, increased rate of respiration occurred, followed by a decrease. At the point of climacteric for similar but unirradiated fruits, however, treated fruits demonstrated another increase in respiratory activities which would indicate that at this dose level a recovery mechanism from the effects of cathode rays is functional; or more logically that the normal respiratory activities are only incompletely disrupted. Work of a preliminary nature at this institution indicates that the dose level to inactivate typical bacterial and fungal tomato fruit pathogens is less than one-half the minimum dose applied to these fruits which would indicate that sterilization of fresh tomato fruits could be effected with even less disruption of the respiratory mechanism.

Effect on surface color. Development of red color as determined by objective measurements is inhibited by exposure of mature-green fruits to high energy electrons. As compared to the similar unirradiated fruits, an inhibition is apparent which would indicate that the color-development mechanism has been disturbed.

The increase in red color production shown for a time at the high level (1.5 x 10^6 rep) is curious. This may have a corollary (or actually be correlated) with the stimulatory effect previously found for respiratory

activities. It may be that at this high level of irradiation the substrates utilized in the production of red color are made more available to the processes involved; whereas this did not occur at lower levels in that the threshold of ionization phenomena was not reached to allow such a stimulation to be functional.

Individual pigment responses to ionizing radiations. In that the color of tomatoes is an expression of the pigments present *(3)* the reduction of lycopene content following irradiation explains the inhibition of red color development observed by objective surface measurements.

Statistical analyses of the effects of ionizing radiations upon the subsequent development in mature green tomatoes of lycopene, phytofluene, gamma, and beta carotene, indicated highly significant inhibitory effects during ripening upon all pigments except beta carotene, the principal yellow pigment present.

The beta carotene content remained relatively unchanged during the development of red color, which would indicate that beta carotene is not importantly involved in the production of lycopene.

The level of gamma carotene was indicated to be unrelated to fruit maturity but affected by irradiation, which would suggest this pigment to be dynamically involved in the scheme of pigment development.

Phytofluene and lycopene were found to develop similarly in normal fruits and to be inhibited in a like manner in irradiated fruits.

Evidence of an interaction between fruit maturity at the time of treatment and irradiation was demonstrated only in the case of gamma carotene, which is as expected if the content of this pigment is not related to maturity.

In that lycopene is the pigment responsible for red color in tomato fruits and the development of this pigment is associated with fruit maturity, data for this pigment alone indicates that irradiation *does* have an effect on the ripening mechanism. If other pigments are involved in the scheme of lycopene development, it is possible that irradiation techniques similar to those described might well be employed in proving or disproving such a scheme by selecting dose levels which block or enhance the development of particular pigments, but not others.

SUMMARY

The effects of irradiation on some maturation processes of tomatoes were determined.

The respiratory rate of mature green tomatoes exhibited a severe increase proportional to the amount of radiation applied. Irradiation dosages of 0.5×10^6 rep did not completely disrupt the respiratory pattern of maturing tomato fruits and there was a simulated return to the pattern of similar un-irradiated fruits.

The red color development in tomatoes was inhibited by exposure to ionizing radiations.

The beta carotene content of maturing tomatoes was unaffected by irradiation and increased with fruit maturity as was found for normal fruits.

The phytofluene, gamma carotene, and lycopene pigment development was decreased in tomato fruits treated with high energy electrons.

The maturity of fruits at the time of irradiation was not significant as regards subsequent pigment development, except for gamma carotene.

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A New Non-Destructive Method for the Bacteriological Sampling of Meats

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BACTERIOLOGICAL EXAMINATION OF FRESH MEATS usually involves removal of a surface sample which is subsequently ground, diluted, and subjected to conventional methodology for enumeration of bacterial numbers. In our experience, this approach has several limitations. Distribution of microorganisms on the surface of a piece of meat is never regular, and hence multiple samples must be examined to overcome the large sampling errors encountered. Likewise, if conclusions are to be drawn with respect to a given type of meat, multiple samples must be studied. Sampling by removal of surfaces slices or by taking cores from fresh meat cuts or carcasses results in defacing the meat, with consequent downgrading in quality. The necessity for multiple samples, combined with eocnomic losses attending sampling, often limits the scope of bacteriological studies on fresh meats.

We have been interested in the development of a non-destructive sampling method.

Gunderson and Gunderson *(1)* approached surface sampling through the "spot plate" procedure. A metal dish was poured to the brim with nutrient agar. The sterile agar surface was then pressed against the surface to be sampled. The sample dish was then incubated in a sterile petri dish and colonies subsequently counted. This method was used primarily to evaluate the cleanliness of plant equipment. Gunderson, McFadden, and Kyle *(2)* reported using the same sampling procedure on the skin of poultry. In this case, the agar was blended with water, and subsequently plate counts were made from the blended material. The method described below is similar to this, but the equipment demands and mechanics of sample handling are simpler.

MATERIALS AND METHODS

Millipore filters [a] were sterilized in petri dishes in an autoclave. Just prior to using the filters for sampling, they were dipped into sterile distilled water so as to wet the surface. Using sterile forceps and spatula, the filter was pressed against the surface of meat to be sampled and allowed to remain in contact with it for one minute. The filter was removed and placed in a sterile petri dish until the bacteriological analysis was done.

For analysis, filters were placed in wide-mouth round bottles containing chips of broken glass. One hundred milliliters of sterile distilled water was added. The sample was then shaken mechanically (paint shaker) or by hand for 2 minutes. Subsequently, the material was plated according to conventional procedures. Tryptone glucose yeast extract agar was used, and all samples were incubated 3 days at 20° C.

Plug (core) samples of meat were obtained by means of a cork borer, 1 sq. in. in area. Slices of approximately ⅛ in. in thickness were analyzed, using glass chips to emulsify the sample in 100 ml. of sterile distilled water. Again counts were made on tryptone glucose yeast extract agar.

EXPERIMENTAL

A comparison was made between the millipore and plug methods for sampling meat. For this purpose, 10 lamb breasts were obtained in the chilled condition one day after kill. Millipore and core samples were taken from each breast initially and after 1, 2, 3 and 7 days' storage at 36° F. Sampling on the breasts was random, but in each case the 2 types of samples were taken side-by-side on the meat surface. During storage the lamb breasts were wrapped in cellophane. The logarithms of the total counts were subjected to statistical analysis to characterize the relative variability encountered by the 2 techniques. The mean counts obtained for the 10 lamb breasts are shown in Table 1 and appear graphically in Figure 1. There

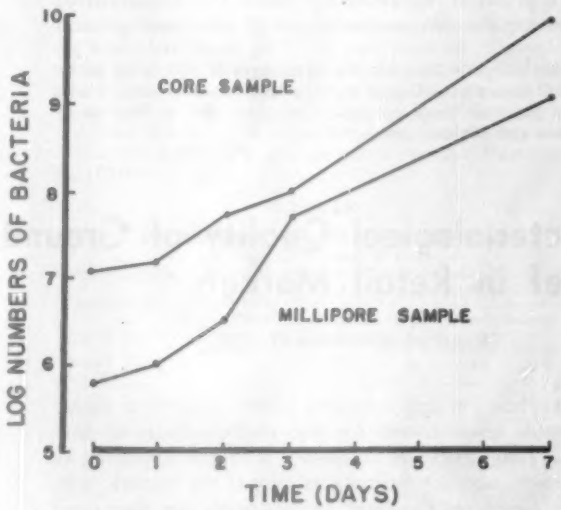

Figure 1. Changes in the total bacteria count of lamb breasts: Core sampling compared with millipore sampling.
Each experimental point represents mean of logarithms of total bacteria counts on 10 different lamb breasts stored at 36° F.

was a significant increase in the numbers of bacteria during storage, and that increase was shown equally well by the millipore and core sampling techniques.

A further comparison of the two sampling methods is shown in the analyses of variance in Table 2. It can be seen that the experimental errors for testing the significance of the storage effect are of the same general magnitude for the two techniques. Therefore, the millipore sampling techniques could be expected to be just as effective as the core sampling procedure in investigating differences in bacterial populations.

TABLE 1

Changes in the total bacteria count of lamb breasts during storage: core sampling compared with millipore sampling

Storage time	Mean of logarithms of bacteria counts [1]	
	Core samples	Millipore sample
Initial	7.149	5.843
1 day	7.283	6.046
2 days	7.741	6.524
3 days	8.005	7.671
7 days	9.882	9.144

[1] Each value represents mean of logarithms of total bacteria counts on 10 different lamb breasts stored at 36° F.

[a] Millipore Filter Corp., Watertown, Mass.; H. A. White, Grid, 047MM Filters.

TABLE 2

Analyses of variance: core sampling, millipore sampling

Source of variance	Degrees of freedom	Mean square	
		Core	Millipore
Storage time	4	12.1153	18.7844
Breasts	9	2.2466	1.9348
Interaction (Experimental error)	36	0.4483	0.3850

DISCUSSION

It is apparent that the millipore procedure [b] for sampling yields counts which are lower than obtained by the plug method. The differences are even greater than is apparent, since the area of surface sampled by the plug is 1 sq. in.; the area of the millipore is 2.5 sq. in. From the standpoint of the utility of either method, this difference in absolute count is of no practical significance. Since the experimental errors for the two methods are of the same general magnitude, one procedure is as good as the other for detecting changes in the bacterial population of meat in response to a specific treatment.

In our laboratories this new non-destructive sampling procedure has made bacteriological studies on a variety of meat products economically feasible. The procedure has been successfully applied to studying various treatments of lamb and beef carcasses and poultry. We have also used the procedure for the surface sampling of plant equipment.

[b] The millipore filter has the advantages of (1) being easily removed from the surface of the meat and (2) when shaken with broken glass, to break up more completely than a filter paper and thus give a better sample.

SUMMARY

A non-destructive method for the bacteriological sampling of meat has been described. The procedure gives results which are as reliable as those obtained using destructive sampling.

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Bacteriological Quality of Ground Beef in Retail Markets

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Ground or comminuted meats provide a highly favorable environment for the multiplication of bacteria. Fragmentation of tissues with the liberation of cell juices and the intimate mixing of the bacteria normally found on the meat surface with the macerated tissues result in a product subject to rapid modification by bacteria.

The uncertain basis for the condemnation of ground meats, consisting largely or exclusively of organoleptic tests, sometimes results in offering for sale products considerably altered by microorganisms. These modified products rarely if ever cause illness in the consumer and the changes resulting from bacterial action may not impair their nutritional value. The altered flavor of the ground meat ("hamburger") after microbial action may be actually preferred by consumers who have become accustomed to it—in the same way that tastes are acquired for certain other foods.

The bacterial population in ground meat is dependent on three main factors: bacteriological quality of the meats used for grinding; cleanliness of equipment; and time and temperature of storage. The numbers of bacteria in market samples of ground meat are clearly indicative of the history of the product.

The obvious relationship of bacterial numbers to quality led to several early investigations of ground meats. Weinzirl and Newton *(8, 9)* suggested that a maximum of 10,000,000 organisms determined at 20° C. be allowed in ground beef. They concluded, however, that there was no close agreement between the actual number of bacteria and degree of spoilage. Carey *(2)* concluded that the determination of mere numbers of bacteria in meat had little significance. Lefevre *(5)* suggested that the bacterial count could be of value in detecting the use of improper materials and defects in handling of the product. He concluded that 1,000,000 bacteria per g., determined at 25° C., was a reasonable maximum to be allowed for ground meat. Elford *(3)* suggested a maximum allowable count of 10,000,000 per g., determined at 37° C. with 48 hours incubation. Tobey *(7)*, however, stated that good hamburger should have a total count not exceeding 800,000, and not more than 200 coliforms per g. Kirsch, *et al. (4)* in their investigations of 20 samples of market hamburger obtained aerobic plate counts which ranged from 1,400,000 to 95,000,000 organisms per g. They found that the hamburger products in their investigations were little if any better in quality than found by those in previous investigations. Seven of the total of 20 samples from 6 markets failed to meet the standard set by Weinzirl and Newton *(8, 9)* and Elford *(3)*, mentioned above.

Modern advances in sanitation and refrigeration have no doubt greatly extended the shelf life of ground meats, but these advances are not assurance that the quality of ground beef offered to the consumer has improved.

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EXPERIMENTAL

Twenty-four retail markets, varying in size from small neighborhood stores to large supermarkets, were selected for study. Four samples, taken on different days (Monday, Wednesday, Friday, Saturday), were obtained from each market. By this means it was hoped that a correct impression would be gained of the quality of ground meat sold by each market. If a market followed the practice of preparing the ground meat daily, as required to meet sales demand, or, on the other hand, if it prepared or procured the meat once or twice a week, the effect on quality might be reflected in the bacterial count on different days. In addition to these studies, 59 samples obtained by inspectors of the Health Department were examined.

Ten-gram samples of the meat were blended with 90 ml. of sterile water for 2 minutes using a Waring blender, and appropriate dilutions by volume were plated out with Difco tryptone glucose extract agar. Four replicate plates were prepared with each dilution; two were incubated at 37° C. for 2 days, the others were kept at 7° C. for 7 days.

Coliforms were determined (as described in *Standard Methods for the Examination of Dairy Products,* 1948) with brilliant green lactose bile (2%) broth (BGB), using 5 tubes of each dilution. Tubes showing gas were confirmed on eosine methylene blue (EMB) agar.

RESULTS

Results obtained in the examination of 96 samples from 24 retail markets are summarized in Table 1. Consistently low counts at 37° C. were found in 8 of the markets (Markets 2, 4, 6, 7, 10, 13, 14 and 17). Others had some low counts and some high counts, but some had no counts below 10 million. Counts made at 7° C. were consistently higher than those made at 37° C. Markets with low counts at 37° C. generally had relatively low counts at 7° C. also. Market 6 was the exception, due to a single very high count obtained on a Monday sample. It is probable that this sample was from meat carried over from the previous Saturday.

The relationship of market size to bacteriological quality of the meat is indicated in Table 2.

The better quality of ground meat sold in the larger markets is probably attributable to two factors. Their meats are usually prepared by the large packers and their turnover is quite rapid. In some instances their refrigeration facilities were better than the storage facilities in the small markets. It should be pointed out, however, that some large markets had counts higher than some small markets. One of the 8 shops with an average count at 37° C. of less than 10 million was a small market.

The day of the week on which the sample was taken was found to have no consistent relationship to the count. In 38% of the markets the lowest counts were obtained on Friday samples; 25% gave lowest counts on Wednesday; the rest were about evenly divided between Saturday and Monday. Highest counts from each market were obtained on Wednesday in 38% of the cases.

In addition to the 96 samples obtained from the 24 selected markets, plate counts at 30° C. were made on 59 samples obtained by an inspector of the Health Department. Of that number, 17 had counts of 10 million or less, 20 had counts between 10 and 100 million, and 33 (37%) had more than 100 million organisms per gram. The highest count obtained was over 2.5 billion per gram. The average count on the 59 samples was 213,000,000 per gram.

Coliform count (MPN) was found to vary widely between samples, and no marked correlation was noted between this group and the plate count. The samples from the 8 markets with average counts of less than 10 million had an average of 76,000 coliforms per gram of meat, and the 6 markets having the highest average plate counts at 37° C. had the same number of coliforms. The general relationship of coliforms to plate counts is shown in Table 3.

For the purpose of comparison, 2 lots of ground beef prepared in the usual manner in the Animal Industry Department of this university were stored at 7° C. and examined at intervals until the meat was definitely spoiled. Results with one of the lots are shown in Table 4.

TABLE 1

Bacterial counts on ground beef in retail markets

	(Counts (x 1,000,000) made at					
	37° C.			7° C.		
Market	High	Low	Average[1]	High	Low	Average[1]
1	50.0	2.0	24.7	110.0	16.5	61.6
2	7.9	1.6	4.6	76.0	3.2	44.9
3	79.5	9.8	31.7	196.0	51.0	115.0
4	3.6	0.9	1.6	6.6	0.9	3.9
5	58.0	17.5	33.1	113.0	38.0	72.0
6	12.5	0.7	5.2	675.0	1.9	213.6
7	6.0	0.4	2.2	32.0	5.7	15.0
8	605.0	4.7	230.0	480.0	4.0	239.4
9	122.5	25.0	51.7	950.0	225.0	613.8
10	5.0	3.1	3.9	39.0	7.6	17.7
11	114.0	7.3	79.8	355.0	75.0	208.5
12	250.5	3.3	91.8	2,540.0	6.7	1,124.4
13	12.3	6.3	9.0	22.5	8.9	15.1
14	7.5	4.0	5.9	180.5	11.5	75.6
15	94.5	7.6	41.8	455.0	90.0	273.8
16	105.5	1.2	30.8	400.0	8.5	122.6
17	6.8	4.7	5.3	145.0	38.0	95.8
18	20.6	3.4	12.0	515.0	6.8	141.9
19	40.1	3.9	13.4	69.0	11.6	51.3
20	20.0	14.9	16.7	170.0	48.5	105.9
21	44.0	32.0	37.6	320.0	157.5	244.0
22	116.0	61.0	82.4	660.0	75.0	287.3
23	13.5	6.2	10.1	465.0	122.0	241.8
24	90.0	39.0	61.6	500.0	48.5	237.0
Average			32.8			192.6

[1] Average of 4 samples.

TABLE 2

The relationship of size of market to quality of ground beef

Market size	Number of markets	Bacteria per gram					
		37° C.			7° C.		
		High	Low	Average	High	Low	Average
		Millions per gram			*Millions per gram*		
Small	9	605.0	0.7	58.4	2540.0	1.9	270.4
Medium	7	122.5	2.0	41.1	950.0	16.5	223.2
Large	8	40.1	0.4	7.3	515.0	2.4	74.1

TABLE 3

The relationship of coliforms to plate counts at 37° C. and 7° C.

Plate counts	Number of samples	Coliforms		
		High	Low	Average
	Counts at 37° C.	*MPN in thousands per gram*		
10^6–10^8	4	24.0	0.65	6.6
10^6–10^7	42	1100.0	0.02	58.7
10^7–10^8	41	790.0	0.07	54.8
10^8–10^9	9	490.0	7.90	156.2
	Counts at 7° C.			
10^6–10^8	1	24.0	24.0	24.0
10^6–10^7	16	110	0.05	16.2
10^7–10^8	37	1100.0	0.02	68.8
10^8–10^9	40	790.0	0.08	77.7
10^9–10^{10}	2	79.0	7.90	43.5

TABLE 4

Plate count and coliforms in ground beef stored at 7° C.

Days stored	Test sample	Plate count/gram		Coliforms
		7° C.	37° C.	
0	a	23,000	12,300	0
	b	25,000	11,250	0
3	a	430,000	480,000	0
	b	420,000	480,000	0
5	a	4,350,000	85,500,000	0
	b	5,900,000	88,000,000	0
7	a	500,000,000	107,000,000	0
	b	650,000,000	105,000,000	0
10	a	3,800,000,000	178,000,000	0
	b	4,000,000,000	179,000,000	0

The highly perishable nature of the product is indicated by the rapid increase in numbers of organisms at 7° C. The low initial numbers are in marked contrast to the high counts found in most market samples.

Changes in bacterial flora during storage were observed in the meat employed in Table 4. At the initial count a hundred colonies were isolated from the plates incubated at 7° C., and the same number from the plates incubated at 37° C. The same procedure was followed after storage for 14 days. The 400 isolates were tested for purity and identified as to genus or species according to *Bergey's Manual (1)*. Results are indicated in Table 5.

TABLE 5

Changes in bacterial flora of ground beef stored at 7° C.

Organism	Isolated at 37° C.		Isolated at 7° C.	
	0 days	14 days	0 days	14 days
Pseudomonas and/or *Achromobacter*	11	64	4	84
Bacillus	8	8	28	6
Flavobacterium	0	6	0	0
Microbacterium	0	7	0	5
Micrococcus	50	14	26	5
Sarcina	6	1	0	0
Yeasts	25	0	42	0
Totals	100	100	100	100

Micrococcus, Bacillus, and yeasts were the most prevalent organisms at the beginning of the storage period; members of the genus *Pseudomonas* and/or *Achromobacter* were most abundant after 14 days storage at 7° C. Kirsch *et al. (4)* obtained similar results. A mixture of gram negative, nonspore-forming rods, and various species of the family *Micrococceae* were predominate in meat when purchased. Organisms that grew most rapidly during storage at 0° C. and 2° C. were motile, non-pigmented members of the genus *Pseudomonas.*

DISCUSSION

Results of this survey of ground beef for sale in retail markets justifies the prevalent idea that "hamburger" meat is often of dubious bacteriological quality. The enormous numbers of bacteria commonly found in ground beef are indicative of poor quality as a consequence of carelessness in the preparation of the product (in meats used or in handling), or else the storage period has been too long or at too high a temperature.

Whether ground meat containing such large numbers of bacteria as reported here is injurious to health or not, it must be obvious that we are dealing with a microbially modified or semispoiled product. There seems to be no good evidence that modern methods of sanitation and refrigeration have succeeded in protecting the consumer from ground beef of very inferior quality, if the bacterial population is a valid criterion of quality.

The coliform count apparently has doubtful significance in ground beef. The numbers found in market samples varied widely and did not correlate well with the plate count. Since no coliforms were found in either of the 2 lots of ground beef prepared in the Animal Industry Department, Louisiana State University, it may be that the presence of coliforms should be considered as evidence of poor sanitation in the production or handling of the product.

SUMMARY

Ninety-six samples of ground beef purchased in local retail markets were found to contain an average of 32,800,000 bacteria per gram when counted at 37° C. and 192,500,000 when incubation was at 7° C. The highest count observed at 37° C. was 230,000,000 and the lowest was 1,600,000. Samples obtained from large markets usually contained fewer bacteria than those from small. Fifty-nine additional samples of ground beef, collected by a sanitarian of the Health Department, were found to contain an average of 213 million bacteria per gram when counts were made at 30° C.

Coliforms were found in all samples in numbers varying from 20 to 1,100,000 per gram; the average was 52,600 per gram. Coliforms were usually, but not always, samples of ground meat prepared routinely in the Animal Industry Department of the university, and the plate counts were less than 100,000 at both 37° C. and 7° C.

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Procedure for Sampling and Laboratory Rendering of Ham Fat and Characteristics Of Hams and Fat During Aging[a]

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DRY CURING OF HAMS is still very important among farmers and some processors and packers. Dunker and Hankins *(5)* reported that 74% of all farm-cured hams are dry cured. Many of these hams are aged before consumption. Methods of curing and aging vary considerably among farmers and processors and even among research workers as shown by Brady *et al. (3)*, Fields and his co-workers *(6, 7)*, Hunt *et al. (9)*, and Miller and Ziegler *(10)*, thereby causing a great variation in the quality of the end product.

Criteria used for determining the quality of hams are partly subjective and partly objective as discussed by Brady *et al. (3)*, Blumer *(2)*, Fields *et al. (6, 7)* and Cecil and Woodroof *(4)*. Even objective methods vary with different techniques of rendering, sampling, and testing. Shrinkage of hams may be tremendous as influenced by time, temperature, and humidity. In view of these problems this test was undertaken to (a) develop a sampling procedure for fat from hams, (b) develop an improved rendering procedure for small fat samples, (c) measure some of the chemical changes in ham fat during processing and aging, and (d) check shrinkage during processing and aging.

EXPERIMENTAL

Rendering. Two methods of rendering small ham fat samples were compared: (a) open air rendering in oven, and (b) vacuum rendering under nitrogen. It has been found under the laboratory procedure used that small samples could be satisfactorily rendered in the oven in one hour at 120° C. or in a vacuum nitrogen flask for 20 minutes at 120° C. Rendering equipment was as follows: A 250 ml. three-necked distillation flask was used for rendering. This flask was heated by a Glas-Col heating element fitted with a voltage regulator control. The top element was maintained at a constant voltage input, while the bottom element was used to control rendering temperatures by use of voltage regulator and thermocouple attached to an ammeter calibrated in degrees centigrade. In one side neck of the flask a thermometer was placed to measure temperature above the sample, the middle neck was used to add the sample and to hold a thermometer to measure sample temperature during rendering, and the other side neck was used to flush the flask with nitrogen and, when rendering, to exert a vacuum by use of a vacuum pump. Approximately 10 minutes was required to bring the sample temperature to 120° C. before starting the rendering period. The drying oven, a Fisher Isotemp, was preheated to 120° C., samples inserted, and the temperature allowed to return to 120° C. before rendering for one hour.

Experimental hams. Skinned hams from 19 Hampshire barrows and 24 Hampshire gilts reared on the Kentucky Agricultural Experiment Station Farm were used. Animals were grown and fattened under uniform environmental and nutritional conditions and were slaughtered at approximately 200 pounds. Carcasses were cut after approximately 48 hours' chilling. Hams were dry cured with a mixture at 7½ pounds of salt, 2½ pounds of sugar, 2 ounces of potassium nitrate and 1 ounce sodium nitrite per 100 pounds meat. Curing period was 21 days at a temperature of 36 to 40° F. (2.2–4.4° C.). Hams were removed from cure, soaked in lukewarm water for approximately one hour, and then allowed to dry before smoking. They were smoked for 14–16 hours at 130° F. (54.4° C.) until they reached a "pecan brown" color. After smoking, hams were placed in an aging room at 70° F. (21.1° C.) with a relative humidity of 50–54%.

Weighing and sampling. Hams were weighed to the nearest 0.01 pound and fat samples were taken from the hams when fresh, after curing, after smoking, and at the end of each month for 6 months. The left ham from each carcass was used to collect shrinkage data and the right ham was used to provide a 25- to 35-g. fat sample. First fat sample was taken from the outside layer of fat over the butt end of the ham, and each succeeding sample was taken closer to the hock but adjacent to the previous sample. Samples were cut into small cubes for rendering. After trial and error this method of sampling was devised so that uniform samples could be obtained at regular intervals without greatly disfiguring the hams.

Chemical tests. Fat saturation was measured by iodine number (Hanus Method) as described by A.O.A.C. *(1)*. Fat oxidation and hydrolytic changes were determined by peroxide number as outlined by Wheeler *(12)* and by free fatty acid content (percent as oleic acid) as described by the A.O.A.C. *(1)*.

RESULTS AND DISCUSSION

Under normal conditions of aging, hams shrink approximately 30% in a year. As the mean annual temperature for Lexington, Kentucky, is 55.1° F. (12.8° C.) it was thought that 6 months' aging at 70° F. (21.1° C.) would accelerate the aging process and produce approximately the same shrinkage as produced by aging for one year under normal conditions. This temperature was also within the range of temperature used successfully by Cecil and Woodroof *(4)*. However, after 6 months' aging some of the hams showed signs of slight deterioration. Therefore the 70° F. (21.1° C.) may be above the optimum temperature for aging dry cured hams for this length of time.

As shown in Table 1, shrinkage increased throughout the processing and aging period with the greatest shrinkage occurring during the first month of aging. As aging progressed the rate of shrinkage decreased.

Effect of rendering methods. The method of rendering the fat significantly affected the peroxide number (Table 2) as shown by analysis of variance *(11)*. The shorter rendering time, the lower temperature and/or the presence of nitrogen decreased the rate of oxidation of the fat during rendering. This difference was shown on samples of fat from the fresh hams, after curing, smoking, and one month of aging. There were no significant differences in iodine numbers or free fatty acid content of the fat due to method of rendering as shown in Table 2.

Fat changes during processing and aging. Since the vacuum-nitrogen rendering method had produced

[a] The investigation reported in this paper relates to a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

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TABLE 1

Shrinkage of hams during curing, smoking, and aging

Period	Cured	Smoked	1 mo.	2 mo.	3 mo.	4 mo.	5 mo.	6 mo.
Average shrink % fresh wt.	2.06	8.61	18.07	22.31	24.90	27.22	28.96	30.48
Standard deviation	0.65	1.10	1.90	2.23	2.32	2.41	2.50	2.56

TABLE 2

Effect of rendering method on peroxide number, iodine number, and free fatty acid content of ham fat

Number of samples	Period	Peroxide number		Iodine number		Free fatty acid content	
		Oven	Vacuum-nitrogen	Oven	Vacuum-nitrogen	Oven	Vacuum-nitrogen
43	Fresh	6.85**	4.75	57.78	58.04	0.23	0.23
43	Cured	8.86**	4.90	59.04	58.95	0.54	0.56
43	Smoked	4.76**	3.10	59.56	59.66	0.96	0.96
43	One Month	7.43**	4.61	59.30	59.41	2.96	2.91

** Significant at the .01 level.

excellent results during the first three experimental phases, it was used during the aging period and the results compared with only the other samples that were vacuum rendered. Table 3 shows the average iodine numbers, peroxide numbers, and free fatty acid contents of these vacuum-nitrogen rendered samples. Iodine numbers indicated that the fat was very saturated for pork fat. They increased slightly but not significantly during the curing and smoking processes then decreased slightly during aging.

Peroxide numbers were erratic during the processing and aging periods indicating that they are unsuitable for measuring rancidity development or "aging" in hams. Evidently, as set forth by Hilditch *(8)*, the peroxides are formed but are broken down into aldehydes and ketones as other peroxides are formed.

Free fatty acids proved to be the most reliable measure of aging. These acids were practically nil in the fresh samples but increased significantly as shown by analysis of variance during the processing and aging periods. In most cases fat from each individual ham showed an increase at each subsequent period.

Chemical data were further analyzed to determine any differences between samples of ham fat from barrows and gilts. There were no significant differences in peroxide numbers or free fatty acid content. However, as shown in Table 4, the fat from barrows was significantly harder and remained harder as shown by lower iodine numbers.

SUMMARY

Hams from 25 gilts and 19 barrows of known history from the Kentucky Agricultural Experiment Station herd were dry cured, smoked, and aged for 6 months at 70° F. (21.1° C.) with a relative humidity of 50–54%. Fat samples were obtained from the adipose tissue on the back of each ham when fresh, cured, smoked, and at monthly intervals during aging. These samples were rendered, and analyzed for iodine number, peroxide number, and free fatty acids.

Two methods of rendering small fat samples were compared: (1) oven at 120° C. for one hour and (2) vacuum flask under nitrogen at 120° C. for 20 minutes. Peroxide numbers from the vacuum-nitrogen rendered ham fat were significantly lower than for the oven rendered. Method of rendering had no effect upon iodine numbers or free fatty acid content. Free fatty acids increased significantly with each period of aging. Ham fat from barrows had a significantly lower average iodine number than from gilts. The free fatty acid content was the only chemical test that was satisfactory to check aging.

During aging shrinkage increased at a decreasing rate each month and ranged from an average of 8.6% after smoking to 30.5% after 6 months' aging.

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TABLE 3

Effect of processing and aging on iodine numbers, peroxide numbers, and free fatty acid content[1] of ham fat

	Fresh	Cured	Smoked	1 mo.	2 mo.	3 mo.	4 mo.	5 mo.	6 mo.
Iodine No.	58.04	58.95	59.66	59.41	59.13	59.17	59.47	58.58	58.59
Peroxide No.	4.75	4.90	3.10	4.61	2.34	3.17	2.81	3.14	2.92
F. F. A.**	0.23	0.56	0.96	2.89	4.68	6.23	7.50	7.98	8.42

[1] Samples rendered under nitrogen.
** Significant at the .01 level.

TABLE 4

Effect of sex on iodine number of ham fat

	Fresh	Cured	Smoked	1 mo.	2 mo.	3 mo.	4 mo.	5 mo.	6 mo.
Barrows**	57.66	58.22	58.70	58.57	58.37	58.74	58.90	58.14	58.25
Gilts	58.34	59.52	60.42	60.08	59.68	59.53	59.94	58.91	58.89

** Significant at the .01 level.

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Development of Jelly Formulas for Use With Fully Ripe Fruit and Added Pectin

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This report describes experiments carried out to determine whether uniform basic formulas for home use in making jellies from fully ripe fruit with the various fruit pectins available on the retail market would be practical.

Initial studies on each of seven fruits were made in the laboratory; then home tests were carried out by homemakers who had previously been on the professional staff of the Human Nutrition Research Division. The home tests were an integral part of the experiment. These technically trained homemakers provided the needed replication of the laboratory studies and, in addition, their work served as a check under home conditions of the formulas and procedures which would ultimately be recommended to homemakers.

EXPERIMENTAL METHODS

Jelly-making materials and equipment. Jellies were made from apples, blackberries, cherries, currants, grapes, plums, and strawberries. Fruits were from various retail sources normally used by those carrying out the studies; all were fully ripe and in most cases of very good quality. More than one variety of most fruits was included.

Two liquid and 3 powdered pectins were investigated; apple and citrus pectins were represented in each of the 2 forms. Pectins for both laboratory and home studies were provided by the manufacturers from stocks of known history. After receipt at the laboratory, the pectins were held at approximately 40° F. and used within 6 months.

Glasses of a prescribed size and shape (6-oz. round bottom optic) were used to obtain comparable yield data from all tests and to provide suitable samples for objective measurements.

Voltage controlled 8-inch electric units were used in the laboratory whereas electric, gas, and bottled-gas home-type ranges were used in the different homes. A torsion balance accurate to 1 g. and a laboratory computagram scale were used in the laboratory; home-type spring scales, all of the same make and indicating 1-oz. graduations, were provided for all workers in the homes. Timers indicating minutes and seconds, 10-quart preserving kettles, and identical measuring equipment were used by all experimenters.

Calculation of formulas. To help determine the formulas to be studied, calculations were made on the basis of the soluble solids content of the jelly ingredients, the estimated average pectin grade of the juice, the amount and grade of the added fruit pectin, and the estimated evaporation loss.

The soluble solids in each kind of fruit were calculated by methods outlined in the *Federal Register (14).*

The grade-ounce content of the liquid pectins under study was 40 to 50 grade-ounces, that of the powdered pectins from 28 to 38 grade-ounces.

A constant of 3.8 ounces was subtracted from the total weight of ingredients as the estimated evaporation loss resulting from 1-minute boiling period. This is an average figure derived from comprehensive jelly cooking data obtained over a period of years by one of the pectin manufacturers.

It was hoped that these calculations would reduce the laboratory work and time required to test the variables and arrive at workable formulas. Similar calculations have been used for some time in the preserving trade where the ingredients and procedures can be carefully controlled. Preliminary laboratory tests indicated that calculations for percent set were useful only as approximations under home conditions.

According to calculations, for each fruit one formula could be used with the liquid pectins, another with powdered pectins. Different formulas were needed for the 2 types of pectins because they were packaged in units quite different in jellying power. The jelly formulas studied are listed in Table 1. As

TABLE 1
Jelly formulas studied

Kind of pectin and jelly	Formulas used [1]					
	Juice		Sugar		Pectin	
	Grams	Cups	Grams	Cups	Grams	Cups
Liquid pectin						
Apple	.....	4.5	.....	7	.....	0.5
Blackberry	978	4	1400	7	241	1
Cherry	872	3.5	1400	7	241	1
Currant	1233	5	1400	7	120	0.5
Grape	1000	4	1400	7	120	0.5
Plum	1000	4	1400	7	120	0.5
Strawberry	971	4	1450	7.25	241	1
					Grams [2]	Packages
Powdered pectin						
Apple						
Formula 1	1774	7	2100	10.5	.....	1
Formula 2	.....	5.5	.....	7	.....	1
Blackberry	858	3.5	900	4.5	.....	1
Cherry						
Formula 1	744	3	800	4	.....	1
Formula 2	.....	4	.....	5	.....	1
Currant	1417	5.75	1400	7	.....	1
Grape	1247	5	1400	7	.....	1
Plum	1254	5	1400	7	.....	1
Strawberry	850	3.5	950	4.75	.....	1

[1] Weights used in the laboratory, volumes in the home experiments.
[2] Weights varied from 70 grams to 100 grams, depending on the pectin under study.

indicated in the discussion of results, the first formulas were not entirely satisfactory in some instances. If fruit was still available, further calculations and tests were made and revised formulas developed. Where 2 formulas are given in the tables, the second is the revision.

Jelly-making procedure. Two or 3 replications of each tentative formula developed in the laboratory were made in home situations, each by a different technician. Procedures standardized in the laboratory were used also in the home studies. Fully ripe fruit was crushed. Juice was extracted without heating when possible; if necessary, the fruit was simmered for a short period in as little water as feasible. Further information on extraction procedures is given in Table 2. Juice was pressed from the prepared fruit and then clarified by straining through several thicknesses of damp cheesecloth.

The amounts of ingredients for each cooking lot were determined by weight in laboratory experiments; in home tests they were determined by volume but weights were also recorded so differences among technicians could be noted.

The order of combining ingredients was determined by the form of pectin. Liquid pectins were added after the fruit juice and sugar had reached a rolling boil; powdered pectins were dissolved in the fruit juice before the sugar was added.

A previous study in this laboratory indicated that boiling jelly for either 1 or 2 minutes after the mixture reached a full rolling boil resulted in satisfactory products. A 1-minute boiling period was decided upon for these studies for any advantage to flavor or yield of jelly that might result from the shorter cooking. Boiling temperature as evidenced by the boiling point of water did not change appreciably during the course of the experiments. Humidity was not controlled and varied with local weather conditions.

Weight of finished jellies was taken immediately after cooking; volume was recorded as the number of 6-oz. glasses of jelly obtained from each cooking lot.

Sensory evaluation of quality. Finished jellies from both laboratory and home tests were rated for firmness, flavor, and general acceptability by a trained panel of 5 members. Preliminary sessions were held to select and train panel members. In these sessions special samples were provided to illustrate jellies varying in firmness, in natural fruit flavor, and in acidity. Since the general acceptability ratings represent the panel members' considered overall estimate of the product based on a combination of factors—appearance, firmness, and flavor—no specific training was given in this category.

Samples were scored for firmness on a 9-point scale with 5 denoting optimum firmness, above 5 too firm, and below 5 too soft. Jellies were turned out of the glasses as a mold just before they were rated. Each person tested firmness of the jellies by (a) slightly moving the plates and observing the amount of quivering which resulted, (b) by cutting her own sub-sample and observing the pressure required, and (c) by putting part of the sample in her mouth and observing the "feel".

Amount of natural fruit flavor was rated on a 5-point rating scale in which 5 represented natural, full flavor and 1, very weak fruit flavor.

A 5-point scale with 5 indicating the best product and 1, the poorest, was used for the general acceptability rating.

The order of presentation of samples to the palatability panel was determined by randomized block statistical designs tailored for use with each kind of jelly according to the number of samples to be evaluated. Comparable jellies from laboratory and home studies were included in the randomization for each kind of jelly. Only 3 or 4 samples were rated at any one session.

Objective measurements of quality. Objective measurements comprised soluble solids content (sugar concentration), pH, and set or firmness of the finished jellies from laboratory and home experiments. For evaluation of these characteristics upper and lower limits were established on the basis of presently available information.

According to reports in the literature, jelly can be made with 40 to 70% soluble solids in the finished product *(9)*. Recommendations of manufacturers of pectin for home use vary from 60 to 70% soluble solids. Commercial jellies on the average vary from 60 to 65% in sugar content unless acidity or pectin is abnormally high *(9)*. For the present studies the range of 60 to 65% soluble solids was selected. Percent soluble solids was determined by a Bausch and Lomb refractometer.

Jelly formation has been reported with pH ranging from pH 2.0 to 3.5, depending on such factors as amount and source of the pectin and amount of sugar present *(1, 8, 9)*. For the present studies with pectins sold for home use, a fairly narrow range, pH 2.9 to 3.5 was used. The pH determinations were made with a Beckman pH meter.

The literature revealed no universally accepted method for determining set of jellies and no standards other than descriptive terms in general use to characterize a satisfactory set. There appears to be agreement that jelly should be firm enough to hold its shape when turned out of the glass yet sufficiently tender to cut easily and to quiver when moved slightly *(6, 9, 11, 13)*.

Objective methods reported for measuring strength or set of jellies include the Tarr-Baker gelometer (Delaware Jelly-Strength Tester) to determine the strength of slices of jelly *(2, 3)*, a jelly-strength testing apparatus to measure resistance to cutting *(12)*, the B.A.R. Tester to measure elasticity *(4)*, an apparatus known as the Exchange Ridgelimeter to measure sag *(5, 7)*, a Rigidometer to measure rigidity *(10)*, and a Paddle Tester[a] to measure resistance to a paddle revolving at a constant speed in a glass tunnel.

In this study the Paddle Tester was used for determining set. The resistance indicated on the manometer scale of the Paddle Tester was converted into percent of standard strength of set by referring to a table of values supplied with the instrument. The table was based on studies of pectin jellies by Bender *(3)*. For brevity this estimate of firmness is hereafter referred to as percent set. After preliminary tests comparing the percent set data with the palatability scores for firmness, limits of 80 to 100% set were established.

RESULTS AND DISCUSSION

Data from the study are summarized in Tables 3 and 4. Panel mean scores for the lowest and highest scoring cooking lots and also the average of all cooking lots for each sample are given. Ranges as well as averages

[a] Developed by General Foods Corporation.

TABLE 2

Proportions and procedures used for extracting fruit juice

Kind of fruit	Extraction method	Form of preparation for weighing or measuring	Prepared fruit			Water	Simmering time
			Grams	*Pounds*	*Quarts*	*Cups*	*Minutes*
Apple	Hot	Chopped	.....	3.5	.....	3.5	15[1]
Blackberry	Cold	Whole	.....	.....	3	None	None
Cherry	Hot	Crushed	1361	3	1.25	0.5	10
Currant	Hot	Unstemmed	2041	4.5	3.5	1	10
Grape	Hot	Whole	1474	3.25	2.5	1	10
Plum	Hot	Crushed	2041	4.5	2.5	1	10
Strawberry	Cold	Whole	.....	.....	3	None	None

[1] Fruit simmered with water for 10 minutes, then crushed and cooked 5 minutes more.

are included also for pH, percent of soluble solids, and percent set of the finished jellies to make possible comparison with the established ranges. Calculated percent soluble solids and percent set are included for comparison of actual and expected values.

Firmness. The set of jellies is probably the most critical single factor determining the success of the product. Data from panel scores on firmness and percent set determinations were considered together in evaluating results. Correlations are given in Table 5. With 5 out of 7 kinds of jelly the coefficients of correlation of these two methods were highly significant. Blackberry jelly had the highest correlation coefficient, 0.93, showing very close agreement between the two methods of testing firmness. With apple jelly the correlation was significant at the 5% level and with currant jelly the correlation was not significant. Regression estimates (Table 5) show that the optimum panel scores of 5 correspond with percent sets ranging from 85.7 to 93.9 for the different fruits studied.

Panel scores on firmness for individual cooking lots of jellies (Table 3) ranged from 3.5 to 7.1, indicating that a few jellies were slightly too soft and a few slightly too firm. Differences in firmness are to be expected with varying fruit and pectins and with different technicians. However, the majority of the jellies had panel

TABLE 3

Percent set and palatability scores for fruit jellies made with formulas in Table 1 using five different fruit pectins on the retail market

Form of pectin and kind of jelly	Number of replications	Number of values in palatability evaluation	Percent set			Panel mean scores[1] for—					
			Calculated	Actual		Firmness		Flavor		General acceptability	
				Range	Average	Range	Average	Range	Average	Range	Average
LIQUID PECTIN											
Apple Jelly											
Pectin 1	3	30	96.7	77.0– 91.5	86.0	3.5–5.4	4.6	2.7–3.2	3.0	2.8–3.2	3.0
2	3	30	103.7	75.0– 88.0	81.0	4.3–5.3	4.9	3.0–3.3	3.1	3.0–3.4	3.2
Blackberry Jelly											
Pectin 1	3	20[2]	122.7	83.5–102.0	92.0	5.0–5.5	5.2	3.9–4.5	4.2	3.5–4.5	4.0
2	3	20[2]	137.0	79.5–100.0	86.5	4.8–5.5	5.1	4.1–4.5	4.3	4.0–4.5	4.2
Cherry Jelly											
Pectin 1	3	30	117.1	92.0– 94.0	93.0	4.9–5.0	5.0	3.5–4.1	3.9	3.8–4.3	4.1
2	3	30	130.7	90.0– 94.0	92.0	4.8–4.9	4.8	3.8–4.3	4.1	4.0–4.3	4.2
Currant Jelly											
Pectin 1	4	30[2]	111.3	79.0–101.0	91.5	5.2–6.3	5.6	3.4–3.4	3.4	3.2–3.5	3.4
2	4	30[2]	118.3	78.0– 91.0	86.0	4.9–5.9	5.4	2.7–3.7	3.3	2.8–3.8	3.3
Grape Jelly											
Pectin 1	4	40	92.8	71.0– 90.0	80.5	3.6–5.3	4.7	4.2–4.7	4.4	3.9–4.7	4.3
2	4	40	99.7	69.5– 85.5	77.0	3.8–4.9	4.4	4.2–4.6	4.4	4.3–4.7	4.5
Plum Jelly											
Pectin 1	4	40	92.0	75.5– 80.0	78.0	4.3–4.6	4.4	3.1–4.3	3.8	3.2–4.5	4.0
2	4	30	99.0	78.0– 82.0	80.5	4.2–4.6	4.4	3.6–4.1	3.9	3.5–4.3	4.0
Strawberry Jelly											
Pectin 1	5	50	98.3	77.0– 89.5	84.5	4.1–5.2	4.8	3.2–4.5	3.6	3.1–4.5	3.6
2	5	50	112.3	78.0– 88.0	82.5	4.3–5.4	5.0	3.4–4.0	3.8	3.3–3.8	3.6
POWDERED PECTIN[3]											
Apple Jelly											
Formula 1											
Pectin 4	3	....	90.6	69.0– 73.0	71.4	....	....	....	....	....	....
Formula 2											
Pectin 3	3	30	124.0	78.0– 95.0	86.5	4.9–5.4	5.2	3.3–4.0	3.6	3.4–4.0	3.7
4	3	30	113.5	93.0–103.5	98.5	5.0–5.4	5.2	3.2–3.7	3.4	3.3–3.8	3.5
5	3	30	131.9	91.5–100.0	96.0	4.2–5.6	5.1	2.8–3.7	3.2	2.9–3.6	3.2
Blackberry Jelly											
Pectin 3	3	20[2]	143.1	85.5–105.0	92.0	4.9–5.4	5.1	4.2–4.4	4.3	4.2–4.5	4.4
4	3	20[2]	126.3	103.0–135.0	114.0	6.1–7.1	6.5	3.1–3.5	3.3	3.1–3.5	3.3
5	3	20[2]	155.6	83.5–117.0	96.0	5.1–6.9	5.8	4.0–4.3	4.2	4.1–4.4	4.2
Cherry Jelly											
Formula 1											
Pectin 3	2	10	148.2	104.0–113.0	108.5	....	5.5	....	3.8	....	3.9
4	2	10	129.8	111.0–121.0	116.0	....	5.9	....	3.4	....	3.7
5	2	10	161.6	103.0–104.0	103.5	....	5.3	....	4.2	....	4.2
Formula 2											
Pectin 3	3	30	133.2	78.0– 85.0	81.5	4.1–4.6	4.3	4.1–4.5	4.3	4.2–4.5	4.3
4	3	30	118.9	93.5–100.0	96.0	4.9–5.1	5.0	4.1–4.2	4.1	4.2–4.3	4.2
5	3	30	144.2	77.0– 95.5	83.0	4.0–4.7	4.3	4.0–4.5	4.3	4.0–4.4	4.2
Currant Jelly											
Pectin 3	4	30[2]	136.8	77.5– 97.5	90.0	4.9–6.2	5.7	3.4–3.7	3.5	3.3–3.6	3.4
4	4	30[2]	125.9	85.5–110.0	97.5	4.8–6.5	5.9	3.5–4.4	3.9	3.4–4.3	3.7
5	4	30[2]	145.0	87.5– 92.0	89.5	5.0–5.9	5.6	3.3–3.8	3.5	3.3–3.7	3.5
Grape Jelly											
Pectin 3	4	40	120.3	81.0– 97.5	92.5	4.8–6.1	5.6	2.9–3.9	3.6	3.1–4.1	3.7
4	4	40	109.9	82.0–107.0	96.0	4.9–6.3	5.6	3.5–4.0	3.8	3.5–3.9	3.8
5	4	40	128.5	73.0– 99.0	88.5	4.4–6.5	5.2	3.8–4.1	4.0	3.8–4.2	4.0
Plum Jelly											
Pectin 3	4	30	119.6	86.0– 89.0	88.0	4.5–4.9	4.7	2.9–4.2	3.6	3.0–4.5	3.9
4	4	40	109.3	94.0–110.0	100.0	5.0–5.9	5.4	3.0–4.2	3.5	3.1–4.1	3.6
5	4	40	127.7	84.0– 95.5	88.5	4.8–5.7	5.0	2.9–4.3	3.7	3.5–4.6	3.9
Strawberry Jelly											
Pectin 3	5	50	111.0	75.0– 91.0	84.0	4.5–5.6	5.0	2.6–4.5	3.4	2.7–4.5	3.4
4	5	50	95.8	97.0–110.0	101.0	5.3–7.1	6.3	2.8–3.6	3.0	2.5–3.4	2.9
5	5	50	123.5	72.0– 97.5	84.0	3.5–5.8	5.0	2.8–4.5	3.6	2.7–3.8	3.3

[1] Firmness was rated on a 9-point scale with 9 denoting very firm; 8, firm; 7, moderately too firm; 6, slightly too firm; 5, optimum firmness; 4, slightly too soft; 3, moderately too soft; 2, soft; and 1, very soft or no set. Flavor and general acceptability were rated on 5-point scales with 5 denoting very good; 4, good; 3, fair; 2, poor; and 1, very poor.

[2] Average scores for firmness of blackberry jelly based on 30 values; for currant jelly, 40 values.

[3] Powdered pectins No. 3 and 5 were 2½-ounce packages, and No. 4, 3½-ounce package.

TABLE 4

Acidity, soluble solids, and evaporation losses of fruit jellies made with the formulas in Table 1 using five different fruit pectins on the retail market

Form of pectin and kind of jelly	Number of replications	Acidity		Soluble solids			Evaporation loss			
		Range	Average	Calculated	Actual		Range	Average	Range	Average
					Range	Average				
		pH	*pH*	*Percent*	*Percent*	*Percent*	*Ounces*	*Ounces*	*Percent*	*Percent*
Liquid Pectin										
Apple Jelly										
Pectin 1	3	3.5–3.6	3.6	61.9	62.0–63.5	62.8	5.2– 7.2	6.3	5.3– 7.5	6.5
2	3	3.1–3.3	3.2	61.9	61.5–63.5	62.7	3.2– 7.0	5.5	3.3– 7.1	5.7
Blackberry Jelly										
Pectin 1	3	3.3–3.4	3.4	60.6	60.0–63.0	61.3	2.5– 5.0	3.6	2.7– 5.5	3.9
2	3	3.0–3.1	3.1	60.6	59.5–62.5	61.0	3.0– 6.5	4.2	3.3– 7.1	4.6
Cherry Jelly										
Pectin 1	3	3.5–3.5	3.5	64.3	66.5–66.5	66.5	1.5– 7.0	3.8	1.6– 7.6	4.1
2	3	3.2–3.2	3.2	64.3	66.0–67.0	66.5	2.0– 9.5	4.7	2.1–10.5	5.1
Currant Jelly										
Pectin 1	4	3.0–3.3	3.1	58.5	57.5–61.0	59.0	3.1– 5.2	4.3	3.2– 5.6	4.4
2	4	2.9–3.2	3.0	58.5	57.5–60.5	58.8	3.2– 6.8	5.5	3.3– 7.2	5.6
Grape Jelly										
Pectin 1	4	3.0–3.3	3.1	64.3	62.5–64.5	64.0	0.8– 5.2	2.8	0.8– 6.1	3.2
2	4	2.9–3.1	3.0	64.3	63.0–64.5	63.5	2.8– 5.2	3.6	3.1– 6.2	4.2
Plum Jelly										
Pectin 1	4	3.1–3.3	3.2	64.8	63.0–67.5	65.5	2.8– 3.2	3.0	3.0– 3.6	3.4
2	4	3.1–3.2	3.2	64.8	65.0–66.5	65.5	2.2– 3.2	2.7	2.4– 3.6	3.0
Strawberry Jelly										
Pectin 1	5	3.2–3.5	3.4	60.8	60.5–62.0	61.0	3.0– 3.5	3.3	3.2– 3.8	3.5
2	5	2.9–3.2	3.0	60.8	60.0–62.0	61.0	3.1– 4.0	3.4	3.3– 4.2	3.6
							Mean	4.0		4.3
Powdered Pectin[1]										
Apple Jelly										
Formula 1										
Pectin 4	3	3.3–3.3	3.3	63.7	63.3–63.5	63.3	4.2– 4.6	4.4	3.0– 3.3	3.2
Formula 2										
Pectin 3	3	3.1–3.2	3.2	60.4	59.5–64.5	62.2	6.0– 7.5	6.6	5.8– 7.2	6.5
4	3	3.1–3.4	3.3	61.1	59.5–63.0	61.7	5.5– 6.0	5.7	5.3– 5.8	5.5
5	3	3.2–3.4	3.4	60.7	59.5–63.5	61.8	2.5– 6.0	4.3	2.5– 5.9	4.3
Blackberry Jelly										
Pectin 3	3	3.0–3.1	3.0	60.9	61.5–63.0	62.0	2.0– 9.0	4.9	3.1–13.8	7.5
4	3	3.1–3.2	3.2	62.0	62.0–65.5	63.0	3.5– 8.0	5.2	5.2–12.2	7.9
5	3	3.2–3.2	3.2	61.4	61.0–64.0	62.5	3.5– 5.0	4.0	5.4– 7.8	6.2
Cherry Jelly										
Formula 1										
Pectin 3	2	3.1–3.2	3.1	64.1	64.5–65.0	65.0	3.2– 3.6	3.4	5.6– 6.3	5.9
4	2	3.2–3.2	3.2	65.3	65.0–65.5	65.0	3.0– 3.4	3.2	5.2– 5.9	5.6
5	2	3.2–3.3	3.3	64.7	65.0–65.0	65.0	3.5– 3.7	3.6	6.1– 6.5	6.3
Formula 2										
Pectin 3	3	3.2–3.3	3.2	61.3	64.0–71.0	67.0	4.0–17.5	9.0	5.2–22.4	11.6
4	3	3.4–3.4	3.4	62.2	64.0–65.0	64.5	3.5– 7.0	5.7	4.5– 9.3	7.4
5	3	3.4–3.5	3.4	61.7	64.5–71.5	67.0	4.0–13.0	7.2	5.2–17.7	9.6
Currant Jelly										
Pectin 3	4	2.8–3.1	3.0	58.2	58.5–66.5	61.0	5.0– 9.5	6.5	4.9– 8.9	6.3
4	4	2.9–3.1	3.0	58.9	59.0–62.0	60.0	4.7– 9.0	6.7	4.6– 8.4	6.5
5	4	2.9–3.2	3.0	58.5	58.5–61.5	60.0	4.6– 9.0	6.0	4.5– 8.4	5.9
Grape Jelly										
Pectin 3	4	2.8–3.0	2.9	62.7	61.5–64.5	63.0	3.9– 8.0	5.8	4.1– 7.9	6.0
4	4	2.9–3.1	2.9	63.4	62.0–64.0	63.0	4.0– 8.0	5.1	4.2– 7.9	5.2
5	4	2.9–3.1	3.0	63.0	62.5–64.5	63.5	4.0– 8.0	5.3	4.2– 8.0	5.5
Plum Jelly										
Pectin 3	4	3.0–3.1	3.1	63.1	65.0–67.0	66.0	3.5– 6.5	4.8	3.6– 6.5	4.8
4	4	3.0–3.2	3.1	63.8	63.0–67.0	65.0	3.5– 6.5	4.8	3.5– 6.5	4.9
5	4	3.1–3.2	3.1	63.4	62.5–67.0	65.0	3.5– 6.5	4.6	3.5– 6.5	4.6
Strawberry Jelly										
Pectin 3	5	2.9–3.1	3.0	61.3	58.5–64.0	61.5	3.5– 4.1	3.7	5.1– 6.2	5.6
4	5	3.0–3.2	3.1	62.3	59.0–62.5	62.0	3.0– 4.5	3.7	4.3– 7.5	5.6
5	5	3.0–3.3	3.2	61.7	59.5–65.5	62.0	3.0– 4.5	3.7	4.5– 6.5	5.6
							Mean	5.1		6.2

[1] Powdered pectins No. 3 and 5 were 2½-ounce packages, and No. 4, 3½-ounce package.

averages for firmness reasonably close to 5, the optimum score.

Results from the objective test expressed as percent set give a similar picture. Individual cooking lots of jelly ranged from 69 to 135% set. Thus a few lots were outside the established limits of about 80 to 100% set. Here again a large proportion of the samples were within or barely outside these limits. Averages for comparable cooking lots ranged from 71.4 to 116% set, indicating that some of the formulas were not entirely satisfactory.

Some of the apple jelly samples made with liquid pectin were slightly below the lower end of the range recommended for percent set. A change in the formula to yield slightly firmer jellies may be advisable since none of the apple jellies were extremely high in set. With powdered pectins, jellies made by formula 1 were too soft and were not rated by the panel; jellies made by a revised formula (No. 2) were satisfactory.

The formulas used for making blackberry jellies with either liquid or powdered pectins are probably as satisfactory as can be achieved because any change would tend to produce some jellies out of line at one end of the range.

All cherry jellies made with the liquid pectins were close to optimum firmness as shown by both panel scores and percent set data. Formula 1 with powdered pectin yielded slightly too firm jellies and the revised formula

TABLE 5

Correlation of panel scores on firmness and percent set as determined by the paddle tester for seven kinds of jelly

Kind of jelly	Number of values[1]	Mean panel score for firmness	Mean percent set	Correlation coefficient	Regression estimates	
					Optimum firmness score	Corresponding mean percent set
Apple	15	5.0	89.7	0.61*	5	89.8
Blackberry	15	5.6	96.1	0.93**	5	86.0
Cherry	21	4.9	92.0	0.87**	5	93.9
Currant	20	5.6	91.0	−0.08	..	....
Grape	20	5.1	86.9	0.86**	5	85.7
Plum	20	4.3	78.5	0.91**	5	90.2
Strawberry	30	5.1	86.9	0.83**	5	85.7

[1] The number of replications times the number of pectins.
* Significantly different from zero at the 5% level.
** Significantly different from zero at the 1% level.

(No. 2) resulted in some jellies which tended to be too soft. A formula using amounts of sugar and juice midway between those in the two formulas tested probably would be satisfactory.

With currant jellies results from panel scores for firmness and percent set data disagree. Judges rated all currant jellies as optimum in firmness or slightly too firm whereas percent set data classified a few samples as slightly too soft. Since eating quality is the ultimate test, the panel scores for firmness were given more weight than the other data.

In grape jellies the formula with liquid pectins produced too soft products in some cases. With powdered pectins a too soft jelly resulted in only one instance: all jellies from one lot of grapes (data not shown) were softer than from the other lots; however, in several cases the softer jellies were considered by the panel to be nearer optimum firmness than any of the comparable replicate samples.

Plum jellies made with the liquid pectins tended to be slightly too soft. The formula used with the powdered pectins produced satisfactory plum jellies.

Some cooking lots of strawberry jelly made with both liquid and powdered pectins were slightly too soft.

Since the softest jellies from all the fruits were described as being only slightly to moderately too soft, it is probable that only minor formula revisions to improve jelly texture are needed. The nature of the change in each case would depend on such factors as the soluble solids content and pH of the jellies made with the present tentative formulas.

Flavor. Panel estimates for flavor were considerably more difficult to evaluate than those for firmness. Problems due to the complexity of the combination of fruit, acid, and sweet flavors and the satiety factor in tasting jelly were very difficult to solve.

Flavor scores for all jellies tasted ranged from 2.6 to 4.7, denoting variation from rather weak fruit flavor to almost full flavor. Jellies from most of the fruits were represented in both of these flavor categories, probably because of flavor differences in the various lots of fruit used and the blending of the fruit flavor with different acid ingredients of the various pectin products.

The pectin products were found to influence flavor somewhat; for example, pectin 1 was very mild and bland and pectin 3 tended to be tart. It is understandable that some fruit flavors might be enhanced by the tartness of a certain pectin product whereas others might be preferable with a bland product. For instance, blackberry jelly made with one of the powdered pectins was less pleasing in flavor to the panel members than the jellies made with the other two powdered pectins; however, currant jelly using this particular pectin product was scored slightly higher than those made with the other pectins.

Some cooking lots of jelly from each fruit rated 4.0 or higher, which shows that it was possible to make flavorful jellies by the formulas under test.

General acceptability. Scores for general acceptability, which includes appearance as well as flavor and firmness, ranged from 2.5 to 4.7 about the same range as in flavor scores. Both low and high scoring individual cooking lots of jelly were represented among samples from most kinds of fruit.

Acidity. The pH range for all jellies prepared from all fruits was from 2.8 to 3.6 (Table 4). Five cooking lots were barely outside the established range (pH 2.9 to 3.5). Three of these were slightly more acid than desirable (pH 2.8) and syneresis could result; however, they all set satisfactorily and no syneresis was noted. One sample was scored down somewhat on flavor and may have been too tart.

Two cooking lots had pH 3.6 which could yield jellies with low set. One had good texture and the other was slightly soft, although both contained 63% soluble solids which should promote proper set if other conditions are right. Neither of these samples, made from sweet apples, had particularly good flavor; they might have been improved with added acid.

Jellies made from blackberries, cherries, currants, grapes, or plums showed slightly less variation in pH from one lot of fruit to another than those made from apples and strawberries. Cherry jellies tended to be toward the upper end of the optimum pH range; currant and grape jellies, toward the lower end.

In general, more variation in pH was evident among the samples of jelly from the same lot of fruit made with different pectins than among those from different lots of fruit made with the same pectin.

Soluble solids. Calculated soluble solids for all fruit jellies except currant were within the range considered suitable for homemade jellies, approximately 60 to 65% (Table 4). With currant jelly the lower soluble solids content (around 58 to 59%) was expected to be satisfactory because with fruits high in natural pectin a lower soluble solids content may prevent too stiff a jelly. Also the actual soluble solids in the finished jellies are often slightly higher than the calculated figures.

In most of the finished jellies soluble solids were within or very close to the established limits. Some lots of currant jelly had soluble solids content of 57.5%, slightly below the desirable range, while other lots made from the same formula were within the range. Panel members considered all of the currant jellies satisfactory in set; flavor scores for one sample were low but no cause for this is apparent from the data since other samples made from the same fruit and having similar soluble solids content were scored higher.

Jellies which were above the upper limit of the soluble

solids range included some cooking lots of cherry and plum jelly made with the various liquid and powdered pectins and one of the currant jelly made with powdered pectin. With one exception, the same formulas also produced some jellies that were within the range for soluble solids: all cooking lots of cherry jelly made with liquid pectin, even those that had the lowest evaporation losses, were above the range. Since palatability scores for these jellies indicate good eating quality, the high soluble solids appear to present no problem.

Evaporation losses. For the 136 cooking lots of jelly included in this study, evaporation losses during cooking ranged from 0.8 to 17.5 oz. (Table 4), showing that in practice a wide variation may be expected among cooking lots of various sizes prepared on different ranges by different workers. Based on total weight of ingredients, evaporation ranged from 0.8 to 22.4% for individual cooking lots. The mean loss for all cooking lots of jelly made with powdered pectin was 5.1 oz. (6.2%) while that for the lots made with liquid pectin was 4.0 oz. (4.3%). These losses are not quite so low as the 3.8 oz. figure used to estimate evaporation losses in making formula calculations.

Loss by evaporation was significantly larger for jellies made with powdered pectins than for those made with liquid pectins. This may be due partly to a difference in the rate of evaporation of the solutions resulting from the two methods of combining ingredients and from different concentrations of ingredients at different stages in the process. Another factor in this loss may be the slightly smaller volume with the same exposed surface area when powdered pectins were used.

SUMMARY

Basic fruit jelly formulas were developed for use in the home with selected fully ripe fruits and added fruit pectin. Five different pectins available on the retail market were used, including both liquid and powdered pectins from apple and citrus sources. Jellies made from apples, blackberries, cherries, currants, grapes, plums, and strawberries were evaluated on palatability and other quality characteristics. For every fruit, one formula could be used with the liquid pectins; a different one was required with powdered pectins.

Initial studies were made in the laboratory and other replications were made by homemakers in their own kitchens. A trained palatability panel rated samples from both laboratory and home studies for firmness, flavor, and general acceptability. Objective measurements comprised pH, soluble solids, percent set, and evaporation losses.

Published reports, experience of others, and preliminary studies in this laboratory led to the establishment of certain limits for several characteristics—pH 2.9 to 3.5, 60 to 65% soluble solids, and about 80 to 100% set—as necessary for success in jelly making. Evaluation of the jellies on the basis of these limits, together with the palatability ratings, was used to determine the suitability of the formulas studied.

The formulas developed with liquid pectin for blackberry, cherry, and currant jellies and with powdered pectins for apple, blackberry, currant, grape, and plum jellies appear to allow enough margin to be satisfactory with different lots of fruit prepared by different persons; with the other jellies studied small changes in the formulas are needed to improve the chances of success. Results of these studies indicate that uniform basic jelly formulas for home use are practical.

Correlation coefficients from 0.61 to 0.93 between panel scores on firmness and percent set determinations on the jellies were significant for six of the seven kinds of jelly tested.

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Effect of Ionizing Radiations on Southern Oysters[a, b]

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ALTHOUGH MUCH INVESTIGATION of food preservation by cold sterilization through ionizing radiations is now in progress, no one has yet reported any such investigation with oysters. The present study involved the determination of whether or not oysters can be irradiated at dosages high enough for partial or complete sterilization without producing undesirable side reactions. Also determined was the extent to which irradiation of the oysters inhibited souring and pH changes in uncooked oysters. These are believed to be due to enzymatic action.

In general, enzyme systems cannot be inactivated at sterilizing dosages of radiation *(9)*. However, an interesting problem in oysters is that the glycolytic enzyme systems presumably responsible for souring are dependent upon free sulfhydryl groups *(4)*, and sulfhydryl enzymes have been reported to be much more susceptible to radiation inactivation than other types of enzymes *(1)*.

MATERIAL AND METHODS

Raw material. All oysters used in this study were of the species *Crassostrea virginica*, tonged from Cat Point Reef in Apalachicola Bay. Some were tonged directly and others were purchased either in the shell or freshly shucked from a commercial packing house in Apalachicola, Florida.

Oysters tonged directly were packed in ice immediately and transported in about 3 hours to the laboratory, where they were sometimes shucked upon arrival and sometimes kept on ice overnight and shucked the following morning. They were dry shucked into their own liquor and immediately washed by suspending in tap water for approximately 30 seconds after the shucking liquor was discarded. Shell oysters obtained from the packing house had been tonged the day before being transported to the laboratory. They were not iced from the time of tonging until their arrival at the laboratory, where they were immediately shucked and washed in the manner described above. The initial pH was then measured, and the oysters were prepared for irradiation immediately.

Commercially shucked oysters were shucked into buckets of water at the packing house on the morning after tonging, placed on the skimmers, sprayed with fresh water, and drained for 5 minutes before packaging in metal friction-top cans. These were packed in ice and transported to the laboratory in about 2 hours. The initial pH was measured immediately, and the oysters were prepared for irradiation.

Radiation source. All experiments were done with Co^{60} as the radiation source. The gamma ray emission of this source was initially determined to be 3.58×10^5 rep per hour. After 6 months and one year it was calculated to be 3.34×10^5 rep per hour and 3.14×10^5 rep per hour, respectively.

Procedure. The irradiation was carried out either in glass vials with screw-on plastic tops or in glass test tubes sealed with tight-fitting corks which had been dipped in melted paraffin. In some experiments, a small piece of lead acetate paper was attached to the inner side of the screw-on top or the cork of each container at the time of sealing for the purpose of indicating the presence of hydrogen sulfide when the containers were opened.

Both irradiated samples and unirradiated controls were at room temperature during the radiation period after which they were stored either in the refrigerator (5° C.) or at room temperature. Immediately after radiation and at periodic intervals an irradiated and a control sample tube from each experimental treatment were opened and compared with respect to odor and appearance of oysters and liquor. In the raw oysters, the presence of free sulfhydryl groups was determined qualitatively by the nitroprusside test *(10)*, qualitative catalase activity was tested with 3% hydrogen peroxide *(3)*, and the pH followed with a Beckman Model H2 pH meter.

RESULTS AND DISCUSSION

Uncooked Oysters

Lower irradiation dosages. In the first experiment, raw oysters were radiated for periods of 10 to 100 minutes, corresponding to dosages ranging from 6.3×10^4 to 6.3×10^5 rep. They were stored at 5° C.

Immediately after irradiation, the odor was found to be qualitatively the same as that of controls, but slightly stronger. The irradiation produced no change in appearance of the oysters. However, in all cases the liquor was more turbid in the irradiated samples. Sulfhydryl and catalase tests were still strongly positive.

The spoilage pattern was similar in irradiated and control oysters, the odor progressing during refrigerated storage from fresh to stale to slightly sour, but the characteristic odor was always more intense in the irradiated samples. The pH dropped in both control and irradiated samples. (Table 1).

It was concluded from this experiment that radiation doses at least up to 6.3×10^5 rep were not sufficient to retard the spoilage of fresh uncooked oysters. Doses within this range have increased the storage life of some products, notably fresh meats, by reducing certain vegetative organisms; however, in order to bring about complete sterilization, doses of 1 to 4×10^6 rep are required.

Sterilization doses. Radiation doses for fresh, whole oysters were increased to the range 8.3×10^5 rep to 3.5×10^6 rep. Except for increased turbidity of the liquor, no change in appearance of the oysters was noted. In all cases, nitroprusside and hydrogen peroxide tests were still strongly positive, indicating that free sulfhydryl groups and catalase in oysters are not inactivated at sterilizing doses of radiation. Hydrogen sulfide did not appear in the irradiated samples. It developed only during subsequent spoilage of the controls.

An off odor described as "grassy" was evident in the oysters immediately after irradiation at dosages of 8.3×10^5 rep and above, and this odor persisted throughout refrigerated storage, gradually becoming a sour-grassy odor. It could not be eliminated by washing the

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TABLE 1
pH of irradiated and unirradiated raw oysters stored at 41° F. (5° C.)

Days of storage after irradiation	pH							
	10 minutes 6.3 x 10^4 rep		20 minutes 1.26 x 10^5 rep		50 minutes 3.16 x 10^5 rep		100 minutes 6.33 x 10^5 rep	
	Irradiated	Control	Irradiated	Control	Irradiated	Control	Irradiated	Control
0			5.99	6.00	5.92	5.92	6.02	5.90
1	5.80	5.80						
4			5.70	5.75	5.73	5.72	5.70	5.70
6	5.65	5.62						
13	5.65	5.62						
14			5.62	5.64	5.75	5.62	5.78	5.65
20	5.60	5.60						

oysters with water immediately after irradiation. However, upon subsequent cooking the grassy odor disappeared. The cooked irradiated oysters were stronger in odor than fresh cooked oysters, but the odor was not foreign or undesirable.

The pH of one lot of irradiated raw oysters which received 1.7 x 10^6 rep was followed during subsequent storage at 5° C. for about 2 weeks and these values are given in Table 2. The pH of the irradiated samples decreased also, somewhat irregularly, becoming the same as the control after 12 days of storage. The rather large decrease in pH during the irradiation period may be attributed to the fact that the oysters were at room temperature (75° F.) during that time (5 hours).

Since raw oysters irradiated with sterilizing doses undergo both the souring and drop in pH of the unirradiated controls, it may be inferred that endogenous enzymes rather than bacteria are responsible for these symptoms.

Cooked Oysters

Fresh oysters were drained and cooked in glass beakers submerged in boiling water for 6 minutes, at which time the temperature of the oysters reached 158° F. (70° C.) and catalase was completely inactivated. The oysters were packed in glass vials with screw-on tops and radiated at room temperature for 4 hours and 52 minutes (1.69 x 10^6 rep). As controls some samples cooked in the same manner were not radiated but were held in closed glass vials at room temperature for the same period of time.

Immediately after radiation, the containers were opened. The odor of the control samples was unchanged, while that of the irradiated samples was an "oxidized" off odor, difficult to characterize, but considered to be more objectionable than that of oysters radiated raw and subsequently cooked. There was no evidence of the presence of hydrogen sulfide in any of the vials as shown by lead acetate paper which was attached to the inner side of the top of each vial at the time of sealing.

TABLE 2
pH and odor of irradiated (1.7 × 10^6 rep) and unirradiated raw oysters stored at 41° F. (5° C.)

Days after irradiation	Irradiated oysters		Unirradiated oysters	
	pH	Odor	pH	Odor
Immediately before irradiation	6.02	Fresh	6.02	Fresh
Immediately after irradiation [1]	5.68	Grassy	5.79	Slightly stale
3	5.62	Grassy	5.72	Slightly stale
6	5.65	Sour-grassy	5.65	Sour
8	5.74	Sour-grassy	5.59	Sour
10	5.63	Sour-grassy	5.55	Sour
12	5.52	Sour-grassy	5.50	Sour

[1] Both irradiated and unirradiated samples were held at room temperature (73° F.) for 5 hours which was the length of the radiation period.

Oysters with Free Radical Acceptors

It was considered possible that the grassy odor is the result of oxidative changes produced by free radicals which may be formed during irradiation. An investigation of this possibility was made by radiating the uncooked oysters in the presence of various substances known to be free radical acceptors or antioxidants.

Oysters were drained and weighed. To the drained liquor was then added ascorbic acid at concentrations equivalent to either 0.1% or 0.5% of the original weight of the oysters and liquor. The pH of the liquor was then adjusted to its original pH of 6.38 with normal NaOH, and the liquor and oysters were combined, packed into tubes, sealed and radiated at 1.7 x 10^6 rep. Neither concentration of the ascorbic acid prevented the grassy odor, which was evident immediately after radiation and persisted throughout a storage period of 2 weeks at 41° F. (5° C.). The failure was thought to be due to the fact that ascorbic acid is a relatively radiosensitive compound, quickly destroyed. Since niacin, a relatively radioresistant compound, has been shown to protect ascorbic acid *(5, 6, 7)*, a mixture of the two was then tried. To the oysters containing 0.1% or 0.5% ascorbic acid was added niacin in an amount which was 50% of the weight of the ascorbic acid. This mixture was also ineffective in preventing the grassy odor.

The same procedure was followed with 0.1% of a commercial liquid smoke [c] and with 0.5% of a commercial antioxidant mixture [d] containing 20% butylated hydroxyanisole, 4% anhydrous citric acid, 2% nordihydroguaiaretic acid, and 74% propylene glycol. However, neither of these was effective in preventing the undesirable odor.

Similar attempts to prevent the off odor development in cooked oysters during radiation were also unsuccessful. When 0.1% of the previously mentioned commercial antioxidant mixture or commercial liquid smoke was added to the cooking water alone or with ascorbic acid, it did not prevent an "oxidized" odor from

[c] Imitation Hickory Smoke Flavor 51.675 A, Firmenich Inc., New York.

[d] Tennox N, Eastman Kodak Company, Kingsport, Tennessee.

developing in the cooked oysters during subsequent radiation.

Previous studies *(3, 8)* have shown that the above antioxidants retard oxidation of unsaturated fats and the resulting off odors in non-irradiated cooked stored oysters. The inability of these compounds to eliminate the "grassy" odor of raw irradiated oysters or the "oxidized" odor of cooked irradiated samples, would indicate that these off odors developed during radiation do not arise from fat oxidation.

Oyster Liquor

The turbidity of the liquor (in contact with oyster), which was noted immediately following radiation, was not observed when the liquor was radiated alone at doses as high as 8.44×10^5 rep. An oxidized odor resembling coconut milk was present immediately after radiation, but there was no further change in odor or appearance during 3 weeks of storage at 41° F. (5° C.). Unirradiated liquor held at the same temperature for the same period became very turbid and putrid.

POSSIBILITIES FOR RADIATION PRESERVATION

It is not possible from the results of this limited exploratory study on radiation of raw and cooked oysters, to make definite recommendations for the radiation preservation of oysters. Such recommendations will have to await future experiments with a radiation source capable of treating much larger samples of oysters for storage tests at various temperatures. However, the evidence available indicates that radiation preservation of oysters in the raw state does not hold great promise because of continued undesirable enzyme activity even at refrigeration temperature.

From evidence obtained on small samples stored for brief periods only, the most promising procedure appears to be radiation of the raw oysters at sterilizing doses in sealed containers followed immediately by sufficient heat treatment to destroy enzymes. Oysters preserved in this way could, of course, be utilized only in cooked oyster dishes, since the heat treatment necessary to inactivate enzymes produces a cooked product. It is possible that doses considerably below sterilization, coupled with enzyme inactivation and refrigeration, could extend the marketable life significantly. This possibility has not yet been investigated.

RADIATION OF LIVING OYSTERS IN SHELLS

A study was made to determine the dosage at which living oysters would be killed by radiation and also to determine whether the shell would open immediately or remain closed when death occurred in this manner. For this study small Cat's Paw oysters were obtained from the Florida State University's Marine Laboratory at Alligator Harbor.

The living oysters were put into dry polyethylene bags and radiated at room temperature at levels ranging from 5.4×10^4 rep to 7.34×10^5 rep. None of the shells opened during radiation at any of these levels. Immediately after radiation the oysters were put into beakers of water obtained from their natural habitat at Alligator Harbor and observed for opening of the shells. All oysters which received 3.26×10^5 rep or more did not open until about 7 hours after radiation and these did not close when touched, the animals apparently having died during radiation or shortly thereafter. Below this dosage the oysters were not adversely affected.

It was hoped that radiation of the oysters in shells might be used as an effective means of opening the shells for removal of the oysters for canning purposes without causing shrinking of the meats such as occurs in the present industrial method of steaming. However, these results indicate that a fairly high dose of radiation is necessary to kill the oysters, and the shells do not open immediately when death is brought about in this manner.

SUMMARY

Radiation of raw oysters with gamma rays up to doses of 3.5×10^6 rep produced an off odor described as "grassy". Neither free sulfhydryl groups nor catalase activity was noticeably reduced. Subsequent souring and fall in pH occurred both in irradiated oysters and in unirradiated controls, indicating that this type of spoilage is probably caused by enzymes within the oyster rather than by bacteria.

The radiation of cooked oysters produced a somewhat different type of off odor described as "oxidized." The development of off odors was not prevented by the addition before radiation of various antioxidants and free radical acceptors.

The most acceptable irradiated products after brief storage periods were those radiated raw but subsequently heated sufficiently to destroy enzymes. The heating eliminated the grassy odor as well as prevented subsequent enzymatic souring.

Radiation of live oysters in the shell was not found to be an effective means of opening the shells for removal of oysters. Fairly high doses were required to kill the oysters and the shells did not open immediately after killing doses.

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De-Oiling of Peanuts to Yield a Potentially Useful Food Product[a]

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PEANUTS PRODUCED DOMESTICALLY are consumed mostly in the form of roasted nuts, peanut butter, and candy. The market for edible peanuts might be expanded somewhat and at the same time a new, useful food item might be obtained if all or part of the oil could be removed without affecting the kernel structure. Removing the oil would reduce the caloric value of the peanut, a worthwhile objective at a time when increasing numbers of individuals are becoming calorie conscious.

Peanut kernels contain about 50% by weight of oil. As a food the kernels supply about 5.64 calories per gram of which 80%, or 4.50 calories per gram, is contributed by the oil. If the oil were removed from the kernels without destroying their structure, one would still have the same apparent volume, but caloric value per unit volume would be reduced to 20% of the original. This is equal to a reduction in caloric value of 40% on a weight for weight basis.

Table 1 lists the approximate amounts of the several components of peanuts expected to be present before and after removal of the oil (lipides). The amounts were calculated, on a moisture-free basis, from average values *(5)* obtained from the reports of a number of investigators. As is evident from the table, removal of the oil would result in a product consisting mostly of protein (about 60%) and starch and sugars (about 24%).

TABLE 1

Composition of peanut kernels

Constituent	Amount,[1] %	
	Moisture-free basis	Moisture- and oil-free basis
Lipides	50.0	.....
Protein	30.0	60.0
Crude fiber	2.9	5.9
Nitrogen-free extract	14.0	28.0
Ash	3.0	6.1
Reducing sugars	0.2	0.4
Diaccharides	4.7	9.5
Starch	4.2	8.4
Pentosans	2.6	5.3

[1] Calculated from average values *(4)* obtained from the reports of a number of investigators.

Aside from caloric aspects, the question of whether or not to de-oil peanuts is influenced by several factors. One of these is palatability. The end product must have a good appearance and possess a pleasing flavor and odor resembling those of the original peanuts as closely as possible. Another factor is the economic situation. Can the oil be removed by a process feasible for large-scale use and can the two end products, de-oiled peanuts and oil, be marketed at a price sufficient to cover the cost of raw materials and processing and to provide a reasonable profit?

Objective of the current investigation was to examine in a preliminary manner some of the factors mentioned above, particularly those concerned with the technical aspects of extracting the oil.

EXPERIMENTAL

Materials. Dry-blanched peanuts of the Virginia type were used in most of the experimental work. They were purchased from commercial sources as U. S. No. 1 grade and used as received. In one instance raw peanuts of the Runner type were used after the skins had been removed manually.

Prior to some of the extraction tests, the moisture content of the peanuts was reduced by warming them in a convection oven. Some batches of peanuts were roasted lightly in a convection oven before extraction of the oil; other batches were roasted after extraction.

The petroleum ether employed was a commercially available product consisting essentially of pentanes and hexanes and having a boiling range of 95–138° F. (35–59° C.). The hexane was of the commercial grade generally used for oil extraction. It had a boiling range of 146–157° F. (63–69° C.).

The trichlorofluoromethane was of the grade used in mechanical refrigerators. The acetone employed was of C. P. grade. The isopentane was a highly purified fraction containing a minimum of 99 mole percent of isopentane.

Extraction apparatus and procedure. Preliminary experiments in the removal of oil were carried out by simply allowing the peanuts to soak in solvent at ambient temperatures. At intervals the oil-containing solvent was withdrawn and replaced with fresh solvent. Batch sizes of 1 to 12 pounds of peanuts were employed and just enough solvent was added to barely immerse them.

For most of the experiments the glass apparatus depicted in Figure 1 was used.

The extractor proper *(A)* consisted of a 12-liter, round-bottom flask packed to slightly more than half-full with peanuts. Solvent vapors from a steam-heated boiler *(B)* were passed to the top of a condenser *(C)* whose lower end was inserted in the center neck of the extractor. Solvent from the condenser passed down through the peanuts and then entered an outlet tube at the bottom of the extractor and returned to the boiler. A reflux condenser *(D)* was mounted on a second neck of the extractor and served to hold the system at atmospheric pressure and prevent loss of solvent.

For extractions with trichlorofluoromethane, a normally gaseous material, a stainless steel apparatus similar in essential details to the glass apparatus was employed; the operation was conducted under pressure.

In the various extraction tests samples of peanuts were withdrawn periodically and analyzed for residual oil content by method Ba 3-38 of the American Oil Chemists' Society *(1)*.

Removal of solvent. To remove solvent from the peanuts, in most instances, approximately 300-g. portions of the de-oiled and solvent-laden peanuts were placed on a screen tray measuring 16 x 8 x 4 cm. and set in a small vacuum oven measuring 23 cm. in diameter and 34 cm. deep. Pressure in the oven was maintained at 230 mm. of mercury while air was bled into the oven and over the peanuts at a rate of 250 l. per hour (measured at room temperature and pressure). Temperature in the oven was maintained at 63° C. In one of the tests with trichlorofluoromethane the conditions were changed somewhat: peanuts were placed in a standard laboratory-type convection oven and the temperature was maintained at 100° C.

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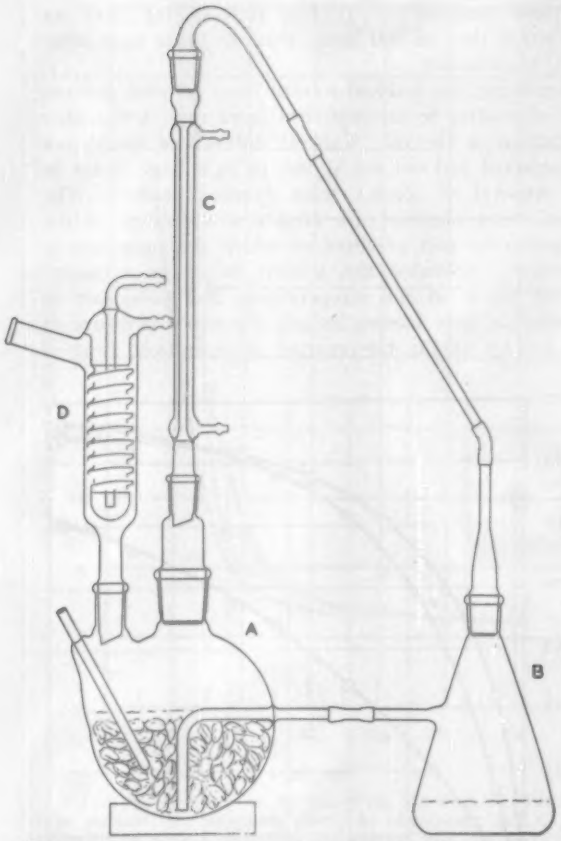

Figure 1. Extraction apparatus: A, extraction flask; B, miscella receiver and solvent boiler; C, condenser; and D, condenser.

In all determinations the tray containing the peanuts was withdrawn periodically from the oven and weighed to determine the amount of solvent removed. When successive weighings showed solvent was no longer being removed at a significant rate and when the presence of solvent could no longer be detected organoleptically, the test was discontinued and residual oil and volatiles (moisture and solvent) were determined on the peanuts using methods Ba 3-38 and Ab 2-49 of the American Oil Chemists' Society *(1)*.

RESULTS AND DISCUSSION

Whole peanuts can be freed of oil by simply soaking in a suitable solvent. This fact is not necessarily obvious and expected. While Fan *et al. (4)* found that the extraction of oil with pentane and hexane from peanut slices, cut so as to leave most of the tissue cells undamaged, followed Fick's diffusion law, they also mentioned that the first layer of kernel cells just under the skin of the peanut greatly retarded extraction by petroleum solvents. Soybeans and possibly certain other oilseeds can not be freed of oil by soaking in a solvent. Othmer and Agarwal *(6)* found that less than 0.19% of the oil in soybeans sliced in half was extracted on soaking them for 168 hours in hexane.

In preliminary experiments it was found that simple soaking in solvents at room temperature removed the oil at a relatively slow rate, but, given enough time, practically all of the oil could be extracted. Varietal differences and any differences in oil content appeared to have no marked effect on the rate of oil removal.

In the preliminary experiments samples of 3 varieties of peanuts, Virginia, Runner, and Spanish were used. Different lots of one of the varieties were tested. Some of the peanut samples were dry blanched, whereas others were water blanched.

Extraction tests even were extended to include almonds, pecans, and cashew nuts. Of these three, oil was most readily removed from the cashew nuts, whereas the almonds for practical purposes could not be deoiled.

In these extractions the oil-containing solvent was withdrawn and replaced with fresh solvent every 3 or 4 days; however, such solvent changes did not appear to be critical. Under the stated conditions, rate of extraction was essentially independent of the concentration of oil in the miscella. This observation is similar to one made by Coats and Karnofsky *(3)* who claimed that rate of solution of the oil in flaked oilseeds is relatively independent of the concentration of the extracting solution.

Any large-scale extraction of whole peanuts would probably make use of the true batch process. The peanuts would simply be placed in large tanks, covered with solvent, and allowed to soak at ambient temperatures for extended periods of time. No special extractors would be required. Even part of the operation of removing residual solvent from the oil-free kernels might be carried out in the tanks used for extraction. Most of the residual solvent could be removed by passing superheated vapors of the extracting solvent over the kernels at atmospheric pressure.

To obtain data on extraction rates for whole peanuts, the semi-continuous method and apparatus (Figure 1) were used. The method tended to minimize any slight effect which the concentration of oil in the miscella might have had on the extraction rate. The solvent was refluxed so that a complete change of solvent took place in the reactor every three or four hours. The extraction curves obtained, together with a curve obtained under comparable conditions with trichlorofluoromethane in an apparatus of stainless steel, are reproduced in Figure 2.

Effectiveness of the extraction is affected significantly by the nature of the solvent. For example, to extract 80% of the oil from the Virginia type peanuts the isopentane required 72 hours; the trichlorofluoromethane, 92 hours; the commercial hexane, 114 hours; and the acetone, 224 hours. Closer control of the temperature at which the extractions were conducted probably would have produced only a small change in the times found.

Trichlorofluoromethane is for economic reasons not a suitable solvent for use in the large-scale extraction of oilseeds. It was tested because halogenated hydrocarbons are known to be powerful solvents for fats and oils. Because this solvent is normally a gas, with a boiling point of 23.7° C. at atmospheric pressure,. it should also be readily removable from extracted kernels.

Acetone not only was a relatively ineffective solvent for extraction; it also tends to extract more non-oil

components than do hydrocarbons. While acetone is not a good solvent for fats and oils, its poor performance probably must be attributed to surface effects when in contact with the tissues of the peanut kernels. One of the authors has observed in previous work that ethanol and certain other oxygenated solvents percolate relatively poorly through crushed oilseeds.

Isopentane not only performed best in the extractions represented in Figure 2, but also is among the best available for the extraction of oil from oilseeds. Ayers and Dooley *(2)* found that of 11 pure hydrocarbons from petroleum, tested in the extraction of cottonseed, isopentane was most efficent. It extracted the greatest amount of oil in a given period of time. Also, the amount of color extracted with the cottonseed oil was low. Of the 11 hydrocarbons tested, only *n*-pentane extracted less color bodies.

The moisture content of blanched peanuts has a marked effect on the extraction rate, as is evident from the extraction curves of Figure 3. The time required to extract a given percentage of the oil from blanched peanuts can be reduced markedly by lowering the moisture content from a value of about 8.5% to below 1%. Further tests showed that heating peanuts beyond the point where nearly all of the moisture has been removed—that is, dry roasting the peanuts—has no significant effect on the rate at which oil can be extracted subsequently. The curves of Figure 3 do indicate that the peanuts containing originally 4% of moisture contain slightly less residual oil after an extraction time of 300 hours than do those containing 0.6% of moisture.

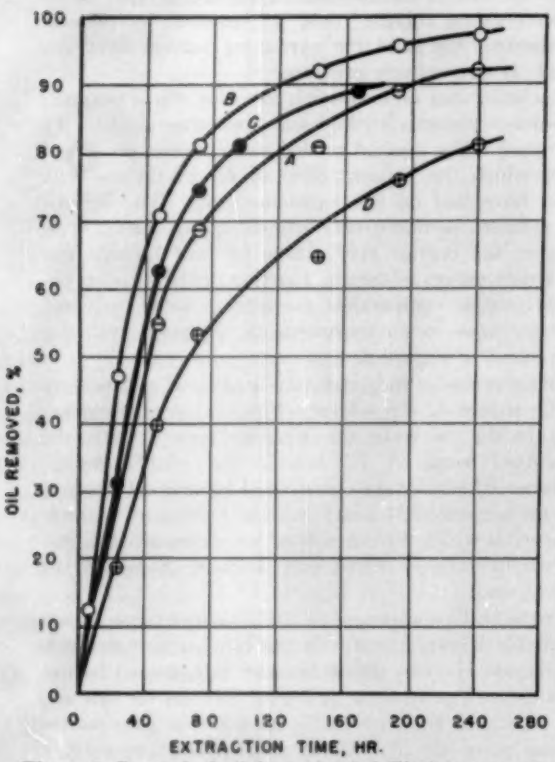

Figure 2. Removal of oil from blanched Virginia type peanuts, moisture content 3%, on extraction with A, commercial hexane at 31° C.; B, isopentane at 26° C.; C, trichlorofluoromethane at 30° C.; and D, acetone at 32° C.

Removing the residual solvent from de-oiled peanuts can, of course, be accomplished more rapidly than the extraction of the oil. Varietal differences would not be expected and did not appear to be a large factor in the removal of solvent from de-oiled peanuts. The actual rates obtained are largely a reflection of the temperatures and presures at which the operation is conducted, provided the solvent exists as a superheated vapor at the temperatures and pressures in question. Other factors include the vapor pressure of the solvent at the temperature of operation, heat of vaporization of the solvent, amount of residual oil in the peanut kernels, and the nature of the solution formed by the solvent and oil. The interrelationship of the several factors on the rate of solvent removal in a given case is difficult to evaluate. Actual curves of amount of solvent removed *vs.* time are given in Figure 4.

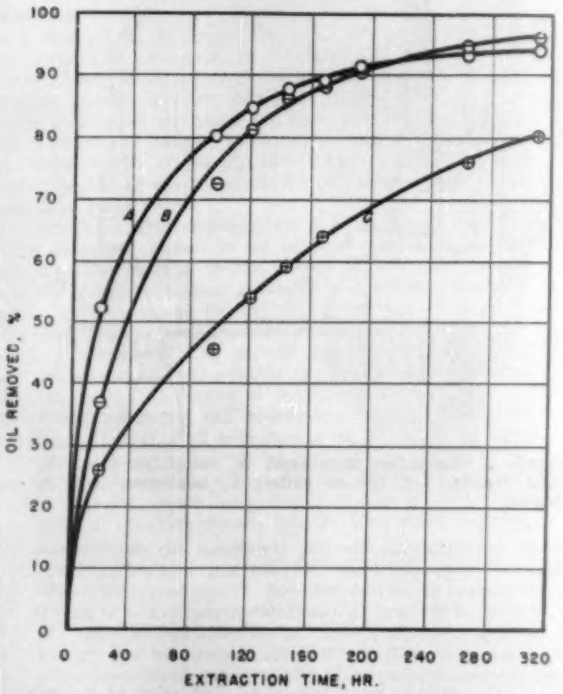

Figure 3. Removal of oil from Runner peanuts by petroleum ether at 33° C.: A, 0.6% moisture in peanuts; B, 4.0% moisture; and C, 8.5% moisture.

Only the lower portions of the desolventization curves are given in Figure 4. Desolventization was started at a volatiles content of about 80%. As is evident, the volatiles *vs.* time curves are quite similar for the 3 solvents. None of the curves reached 0% volatiles because the essentially de-oiled peanuts contained moisture which was not removed under the conditions employed.

An indication of how ease of solvent removal is affected by the oil content of the peanuts is provided by the curves in Figure 5. Since the original kernels contained very nearly 50% of oil, curves *A* and *B* of

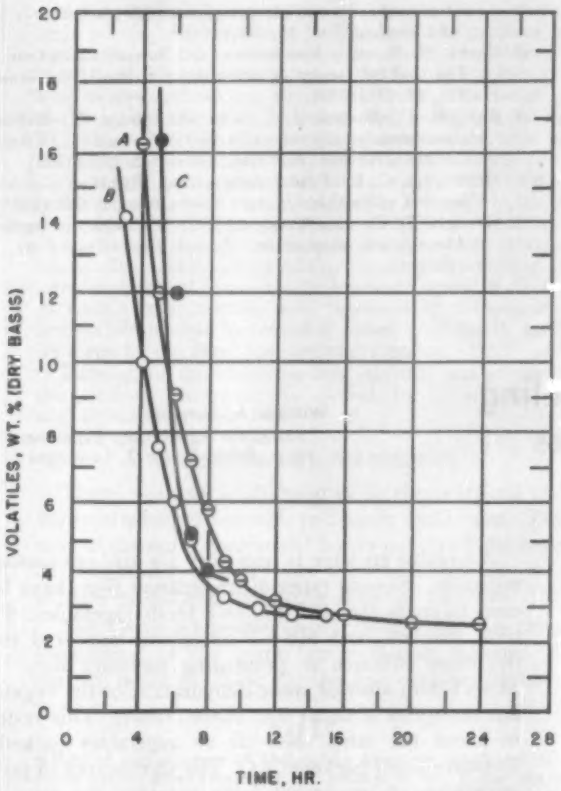

Figure 4. Removal of solvent from the de-oiled Virginia type peanuts: A, petroleum ether; B, isopentane; and C, trichlorofluoromethane. Residual oil content and residual volatiles (moisture), calculated on a dry basis, are, respectively: A, 3.3 and 2.5%; B, 2.4 and 2.7%; and C, 8.4 and 3.9%. Solvents removed by stripping with air at 63° C. and a pressure of 230 mm. of mercury.

Figure 5 represent peanuts from which, respectively, about 92 and 62% of the original oil has been removed.

In appearance the de-oiled peanuts resemble the blanched peanuts from which they are prepared, except that the color is lighter. Usually a practically white product is produced. Roasting, either before or after de-oiling, results in a color which tends to approach that of ordinary roasted peanuts. The outward structure and bulk of the individual kernels do not appear to be changed by the de-oiling process, but the bulk of a batch of peanuts may increase by about 10%, which increase is thought to be caused by a slight warping of some of the individual cotyledons.

Texture of the de-oiled peanuts is firm, but not as firm as that of ordinary oil-roasted peanuts, which may be an advantage. The feel in the mouth is crisp, and there is a slight sensation of chalkiness.

Flavorwise, the almost completely de-oiled peanuts are considerably milder and much sweeter than is the regular product. The flavor, which is characteristic of peanuts, can be enhanced by roasting. Because of the mildness of the flavor, the solvents used in de-oiling must be relatively free of high-boiling contaminants which may remain behind and impair the flavor. Use of ordinary petroleum ether generally results in a slightly bitter product. The strength of the characteristic flavor of peanuts increases in the de-oiled product as the amount of oil left in the product increases. There is a possibility that a commercially desirable product would have only a part of the original oil removed. Samples of de-oiled peanuts have been examined in a preliminary manner by representatives of a number of commercial organizations. General

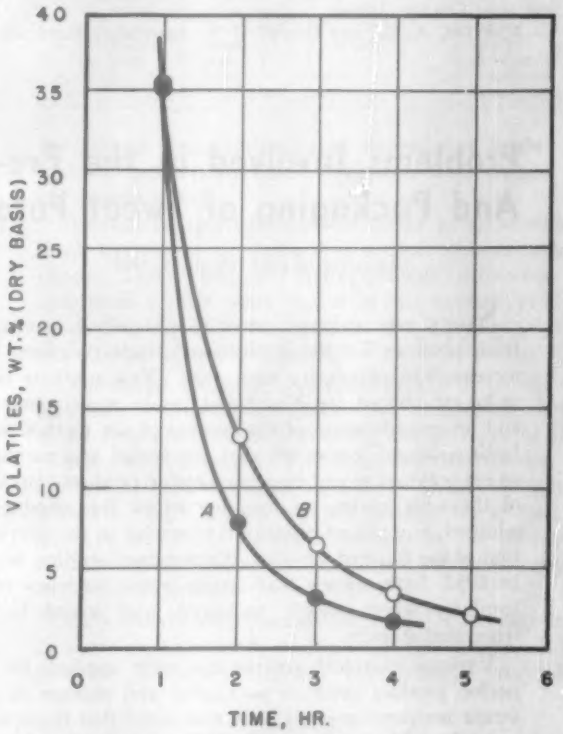

Figure 5. Removal of trichlorofluoromethane from extracted Virginia type peanuts containing A, 8.4% of residual oil and 1.7% of moisture, moisture-free basis, and B, 27.5% of residual oil and 2.2% of moisture, moisture-free basis. Solvent removed by stripping with air at 100° C. and atmospheric pressure.

opinion was that the product is palatable and could be an acceptable food item with respect to flavor, appearance, and texture.

SUMMARY

Whole, blanched peanuts can be freed of oil by soaking them at ambient temperatures in a suitable solvent, like isopentane or hexane. Rate at which oil is removed depends upon operating conditions. Under the experimental conditions employed, at least 60 hours were required to remove 75% of the oil. As the moisture contents of the peanuts increased, the time required to extract a given proportion of the oil increased.

From 4 to 16 hours of stripping with air were required to remove the solvent from the extracted peanuts. The exact time required was dependent upon the pressures and temperatures used.

De-oiled or partially de-oiled peanuts resemble to some degree the ordinary product in appearance and

flavor, though the flavor is relatively mild. These characteristics and the fact that the de-oiled peanuts are relatively low in caloric value suggest that the product may be desirable as a new food for use by a calorie conscious public.

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Problems Involved in the Pre-peeling And Packaging of Sweet Potatoes

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Since the introduction of pre-peeled, packaged Irish potatoes for the institutional trade this item has increased in popularity each year. New markets need to be established for No. 3 and jumbo sweet potatoes, and, in consideration of the success of the method with Irish potatoes, it was felt that pre-peeled and packaged sweet potatoes would be a marketable product. Because of the wide variety of uses for which this product is adapted, any size of potato may be used in the preparation of the finished product. Exploratory studies, begun in 1953, have shown that sweet potato varieties react similarly when peeled, packaged, and stored in refrigerated storage.

Various chemical treatments were applied to the peeled product prior to packaging and storage at different temperatures *(10)*. It was noted that there were several problems involved in the pre-peeling and packaging of sweet potatoes that have not been mentioned as being prevalent in pre-peeled Irish potatoes. One purpose of this phase of the work was to make further investigations on the chemical treatment of the peeled product and if possible to determine by chemical analyses the nature of the changes that occur during the storage of the packaged product. Another purpose was to make a morphological study of the outer anatomical layers of lye-peeled, hand-peeled, and unpeeled samples in an effort to explain the toughening of the outer layers after peeling.

Review of literature. Carbohydrate transformations that occur during curing, storage and cooking have been recorded by several investigators *(3, 5, 6, 10)*. Changes in the amounts of sucrose in sweet potatoes have been used as a measure of the starch degradation rate. Also there appeared to be a critical temperature between 55° and 60° F. as shown by the differences in sugar accumulation *(6)*. There are extreme differences in the carbohydrate contents of sweet potatoes both between varieties and at the various storage temperatures. However, the greatest differences occurred between the 50° and 60° F. storage samples *(10)*.

A suitable package is necessary for any pre-packaged vegetable. Several types of transparent films have been used to study the shelf-life of 8 fresh vegetables. Pliofilm, Vinylite, and MSAT cellophane appeared to be the most effective in preventing moisture loss. The MSAT film allowed more dehydration of the vegetable but the speed of decay was slowed down. This resulted in about the same shelf-life as vegetables packed in moisture proof packages *(4)*. The significance of proper packaging of pre-peeled Irish potatoes has been discussed and evaluated. The main principles to follow for handling potatoes are that the product should be kept cool and packed in packages relatively impermeable to gases, air and moisture *(12)*. In earlier studies the importance of moisture-proof packaging for pre-peeled sweet potatoes was emphasized because of the dehydration of the surface layers and subsequent toughening of the product. Different types of transparent bags were tested for their suitability for sweet potatoes. Pliofilm bags were more effective than other transparent films in preventing the loss of moisture and quality in the pre-peeled packaged product *(11)*.

After storage for 8 days at 35° F. the loss of thiamine in pre-peeled Irish potatoes was found to be about 11 to 13% in whole potatoes and 30 to 47% in French fries *(1)*. The recommended dipping procedure for pre-peeled Irish potatoes was 15 sec. in a solution containing 10,000 p.p.m. of sulfur dioxide.

EXPERIMENTAL

Experiments were conducted on Unit I Porto Rico, Goldrush, Earlyport, and Heartogold varieties over a 3-year period. Storage conditions varied from freshly harvested potatoes to 12 months' storage at 60° F. In most of the studies the product was prepared by peeling in a boiling lye bath for 3-5 minutes. However, a study was made of different lye-peeling temperatures versus hand-peeling. The size of the sweet potatoes was variable, but usually field run stock was used.

After peeling, the potatoes were cut in uniform size pieces and dipped for 2 minutes in the treatment solutions before packaging in polyethylene bags. Four samples were prepared of each treatment for each storage temperature and daily obser-

vations were made for discoloration and condition, although a large portion of the data was filed for reference purposes only.

Samples for the analyses were prepared from medium size stock by slicing the peeled potatoes length-wise and then cross-wise to give uniform size pieces. Twelve of these pieces were placed in each bag after treatment, then sealed and stored at 40°, 55°, and 75° F. Ascorbic acid determinations were made by adapting the method of Morell to sweet potatoes *(3)*. A 25 g. sample was prepared by paring a thin slice from each piece of potato in the sample and placing it directly in the tared flask containing 3% metaphosphoric acid. Then the remainder of the sample was ground in a food chopper and thoroughly mixed. Dry matter determinations consisted of weighing 10 g. samples of ground potato into tin boxes and drying at 70° C. for 24 hours. Sugar contents were measured by the colorimetric ferricyanide method for reducing sugars *(7)*. Starch analyses were run by the direct acid hydrolysis method *(2)*.

Material for the studies on root structure was prepared by the tetrabutyl alcohol-paraffin method, cut 13 μ, and stained with safranin-fast green FCF.

RESULTS AND DISCUSSION

There were slight differences in the reactions of the varieties when pre-peeled, packaged, and stored. Thickness of the outer anatomical layers governed the amount of toughening. There was also a difference in the amount of enzyme darkening between varieties.

The lower lye-peeling temperatures did not prevent toughening of the outer layers during storage. This may be noted in Table 1. The raw samples looked the

TABLE 1

Effect of temperature of lye-peeling upon the toughness of the sweet potato after treatment and storage at 40° F. for one week

Treatment	Condition raw		Condition cooked [1]	
	Flavor	Color	Flavor	Texture
1. 2% DHAS 0.5% Na_2SO_3				
a. 160° F.	very good	bright	good	slightly tough
b. 190° F.	very good	bright	good	good
c. Boiling	very good	bright	good	very good
2. 1% Na_2SO_3 1% NaCl				
a. 160° F.	good	bright	fairly good	slightly tough
b. 190° F.	good	bright	fairly good	good
c. Boiling	good	bright	fairly good	good

[1] Samples were cooked both by boiling and baking with the same results.

same; yet in the cooked samples the outer layers of the 160° F. treatment were noticeably tougher. Results of the hand-peeled samples were similar to the 160° F. treatment and in all instances the boiling lye-peel method gave the better final product after cooking.

These particular chemical treatments that were used in Table 1 have consistently given good results in many previous experiments. The sodium salt of dehydroacetic acid has been termed as toxic in small amounts but in combination with sodium sulfite it was found to be one of the most effective anti-microbial compounds used in this study. Observations on this material are recorded in Table 2. An anti-darkening agent must be added to the dehydroacetic acid salt in order to retain the bright color of peeled sweet potatoes. Other anti-darkening agents were tested for their ability to prevent discoloration, but none of those tested had any marked inhibiting effect on the darkening of the product. A representative number of the materials tested are shown in Table 3. These respective concentrations represent

TABLE 2

Length of storage life of pre-peeled sweet potatoes treated with anti-microbial agents

Treatment	55° F. Storage		40° F. Storage
	8 days	13 days	36 days
1. 2% DHAS	slight disc.	darkened, fair	darkened, fair
2. 2% DHAS 2% Na_2SO_3	very bright	bright, good	good, fair after cooking
3. 1% Sorbic	slight disc.	spoiled	spoiled
4. 1% Sorbic 1% Na_2SO_3	fairly good	spoiled	spoiled
5. 1% DHAS 0.5% Sorbic	slight disc. fairly good	fair	slight disc., spongy
6. 1% Na_2SO_3 1% NaCl	bright, good	spoiled	badly deteriorated
7. Check	spoiled, mold spots	.....	completely deteriorated

the highest concentrations that showed any further inhibiting action when peeled potatoes were dipped for a 2-minute period.

Another compound that was tested in all combinations with those in Table 3 is sodium hexametaphosphate. There was no distinguishable difference in toughness of the outer layers in the cooked product when this material was used in the dipping solution prior to packaging and storage.

A material similar in properties to the dehydroacetic acid salt is O-phenylphenate. This compound proved to be very effective in preventing the spoilage of pre-peeled sweet potatoes. The observations that are recorded in Table 4 reveal that 0.5% O.P.P. combined with 1% Na_2SO_3 preserved the product for as long as 21 days at 55° F. However, because of the off-flavor imparted to the cooked potatoes this material was found to be unsatisfactory.

More attention was focused on the 55° F. storage temperature in this study because of the nature of the product. Generally, in any pre-packaged vegetable,

TABLE 3

Chemical treatment of pre-peeled sweet potatoes and the effect upon color and condition

Treatment	55° F. Storage		40° F. Storage	
	7 days	12 days	7 days	16 days
1. 1.7% Na_2SO_3	very good	spoiled	very good	good
2. 1.0% Na_2SO_3 0.5% Citric	very good	spoiled	very good	good
3. 1% Na_2SO_3 in 20% boiling sucrose	very good	spoiled	very good	good
4. 0.6% $NaHSO_3$ 0.6% Citric	very good bright	fair	very good	good
5. 1.0% Citric 0.2% Sequestrene	darkened	spoiled	darkened	very dark
6. 0.2% Ascorbic 0.2% Sequestrene	spoiled	.....	darkened	spoiled
7. 0.5% Citric 0.2% Sequestrene	spoiled	.....	darkened	spoiled
8. 0.5% Citric	spoiled	.....	darkened	very dark
9. Check	spoiled	.....	darkened	spoiled

lower temperatures down to 32° F. will preserve the quality for longer periods than high temperatures. Yet, since packaged vegetables are handled or displayed in various temperatures of refrigeration during their storage life, it was decided that an average temperature of 55° F. would be the most desirable to use in evaluating chemical treatments.

Several chemical treatments that looked particularly valuable for preserving the color and condition of peeled

TABLE 4

Microbiological properties of O-phenylphenate when used as a dipping solution for pre-peeled sweet potatoes

Treatment	55° F. 14 days storage	55° F. 21 days storage
1. 0.1% O–PP	darkened, good condition	darkened, spoiled
2. 0.5% O–PP	darkened, good condition	darkened, spoiled
3. 0.1% O–PP 0.5% Na_2SO_3	bright color, good condition	[1] fairly bright fair condition
4. 0.5% O–PP 1.0% Na SO_3	bright color, very good condition	[1] bright color good condition
5. 1% Na SO_3 1% NaCl	fairly bright spoiled	dull, badly deteriorated
6. Check	completely deteriorated	completely deteriorated

[1] Bitter off-flavor in raw state as well as cooked.

sweet potatoes were compared as to their effect upon the carbohydrates and vitamins. There are changes occurring in the product during peeling and storage that affect the quality. An analysis was made after treatment and during storage at 40° and 55° F. in an attempt to explain these changes.

Data in Table 5 show that changes in the carbohydrates do occur during lye-peeling. Part of the starch was converted to reducing sugars. These changes continued in storage both at 40° and 55° F. during long storage. The reducing sugars appeared to increase gradually in storage in all treatments, yet the check sample showed the greatest change. The starch decreased as the reducing sugars increased. No attempt was made to explain the increase in sucrose during long storage in the check samples at both temperatures and treatment No. 2 after 14 days storage at 55° F. It is possible that microorganisms were responsible for this change.

There was a loss in dry matter during lye-peeling as noted in Table 6; yet there was no further change during the storage period. The polyethylene bags appear to have prevented the loss of moisture. The changes in carotene content were negligible even though there was some variation. The data reveal very little difference between treatments. This variation was attributed to the differences in samples. Ascorbic acid content dropped to a low level after long storage. The differences in these data on ascorbic acid agreed very closely with the physical condition of the respective samples at the time of analysis. Therefore, the ascorbic acid change could be taken as a quality change in pre-peeled sweet potatoes.

The morphological studies were made on unpeeled, hand-peeled, and lye-peeled sweet potatoes. Slides were made of samples immediately after peeling and at different intervals during the storage period at 40° F. No definite conclusions were drawn from the examination of the material. There was an absence of starch grains in the cortical layer of lye-peeled sweet potatoes compared to the hand-peeled and unpeeled samples. The hand-peeled samples packaged in moisture-proof bags did not develop toughening as rapidly. Therefore, since lye-peeled samples show no starch grains in the outer layer, it may indicate that gelatinized starch is partly responsible for the toughening.

One important point concerning pre-peeled sweet potatoes was noted in this study. It was necessary to cook representative samples of all of the treatments in order to evaluate the results of chemical treatment as physical appearance and flavor of the raw material were not reliable measures of quality. Also, it was noted that the pre-peeled whole potatoes could be wrapped in aluminum foil and baked very much the same way as unpeeled potatoes. The bright color was retained and the quality was excellent.

SUMMARY

The boiling lye-peel method appeared to be the better method of pre-peeling sweet potatoes for packaging and the quality of the product was better after cooking. Several chemical compounds looked particularly promising as treatments for pre-peeled sweet potatoes. It is advantageous for a chemical or combination of chemical compounds to exhibit an anti-darkening effect as well as an anti-microbial effect in the treatment of sweet potatoes. A storage temperature of 55° F. was estimated to be the best to use in evaluating chemical treatments.

There appeared to be no differences between chemical treatments in their effect on the carbohydrates and vitamins during storage after treatment and packaging. The toughening of the cortical layer of the product during storage may be due partly to the gelatinized starch.

TABLE 5

Changes in the carbohydrates of pre-peeled sweet potatoes in storage

Treatment	Reducing sugars	Sucrose	Starch	Total reducing power	Reducing sugars	Sucrose	Starch	Total reducing power	Reducing sugars	Sucrose	Starch	Total reducing power	Reducing sugars	Sucrose	Starch	Total reducing power
Unpeeled fresh	0.70	3.90	11.07	17.10												
Peeled in boiling 20% lye	2.00	4.00	8.85	16.04												
	6 days' storage 55° F.				14 days' storage 55° F.				6 days' storage 40° F.				14 days' storage 40° F.			
1. Check	2.57	3.86	8.47	16.05	5.23	6.15	3.67	15.78	2.61	4.18	8.39	16.33	5.47	6.79	3.58	16.60
2. 0.5% Na_2SO_3 0.5% Citric acid 0.1% Sorbic acid	2.92	4.07	7.72	15.78	5.76	6.94	2.69	16.05	2.84	3.96	7.67	15.53	3.30	4.46	7.50	16.33
3. 0.5% Citric acid 1.0% Na_2SO_3	3.13	3.43	7.69	15.28	3.13	4.06	7.54	15.78	2.61	4.36	7.97	16.05	3.68	4.02	7.58	16.33
4. 1.5% $NaHSO_3$	2.70	3.84	7.69	15.28	3.36	4.60	6.37	15.28	2.57	3.76	9.29	16.85	3.16	4.27	8.50	17.10
5. 1.0% Na_2SO_3 0.5% Citric acid 0.1% O.P.P.	2.77	3.77	8.87	16.60	3.50	4.41	6.43	15.28	2.96	3.39	8.33	15.78	3.62	3.91	6.19	14.62
6. 1.0% Na_2SO_3 0.1% $NaHCL_2$	3.20	3.54	8.46	16.33	3.28	3.72	5.96	13.82	2.80	3.84	8.05	15.78	3.26	4.33	6.94	15.53

TABLE 6

Changes in the dry matter, ascorbic acid and carotene of pre-peeled sweet potatoes in storage

Treatments	Dry matter	Ascorbic acid	Carotene	Dry matter	Ascorbic acid	Carotene	Dry matter	Ascorbic acid	Carotene	Dry matter	Ascorbic acid	Carotene
Unpeeled fresh	24.45	20.90	11.60									
Peeled in boiling 20% lye	22.15	20.58	12.69									
	6 days' storage 55° F.			14 days' storage 55° F.			6 days' storage 40° F.			14 days' storage 40° F.		
1. Check	22.33	11.96	12.39	22.57	12.02	11.50	21.96	14.16	10.19	23.26	11.04	11.70
2. 0.5% Na_2SO_3 0.5% Citric acid 0.1% Sorbic acid	21.55	19.24	11.12	21.92	11.26	11.31	21.42	17.48	11.03	21.92	12.02	10.75
3. 0.5% Citric acid 1.0% Na_2SO_3	21.22	16.46	11.21	21.99	12.76	10.56	22.46	15.76	11.21	22.82	15.49	11.89
4. 1.5% $NaHSO_3$	21.58	14.73	10.28	22.11	12.38	11.31	22.43	17.21	11.31	23.39	16.46	12.39
5. 1.0% Na_2SO_3 0.5% Citric acid 0.1% O.P.P.	22.13	16.84	11.12	21.98	12.98	11.50	21.09	19.68	10.93	21.86	13.84	11.12
6. 1.0% Na_2SO_3 0.1% $NaHCl_3$	22.24	18.44	11.60	20.37	12.02	9.65	21.32	17.00	10.75	22.31	12.98	11.89

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The Time-Temperature Tolerance of Frozen Foods. V. Texture Stability of Thickened Precooked Frozen Foods as Influenced by Composition and Storage Conditions[a]

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Undesirable texture changes are encountered in the freezing and storage of cooked foods thickened with eggs or the usual starchy thickening agents. The texture of sauces, gravies, puddings, and custard-type desserts changes from a smooth to a grainy or lumpy consistency when these foods are thawed immediately after freezing. When the products are subjected to frozen storage, a curdled appearance and visible liquid separation develop; and the original smoothness is not completely regained even in the foods that can be reheated for serving.

Previous studies have established the beneficial effects of waxy rice flour in improving stability of these products *(5, 6)*. The storage time without texture changes is increased, and products that have separated regain their original smoothness on reheating. By using waxy-rice flour, changes can be prevented at 0° F. for a year in sauces and gravies and for several months in thickened desserts. However, at 10° F. (−12.2° C.) texture changes generally occur within a few weeks. Because of the marked difference in texture stability of these foods at 10° F. and 0° F., it appeared that temperature fluctuations in the range encountered in commercial distribution might be of considerable damage. The experiments described in this paper were undertaken to determine the effect of temperature fluctuations

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Mo., June, 1956. The first article in this series *(13)* described the objectives and general plan of the time-temperature tolerance investigation.

on thickened precooked frozen foods and to devise means of making these foods more stable to adverse temperature conditions.

The effect of constant and fluctuating temperatures in the range of —10° to 10° F. (—23.3° to —12.2° C.) has been investigated for 3 typical starch- or egg-thickened products, selected to include a broad range of stability at 0° F. (—17.7° C.). The least stable of the 3 test products can be stored for 1.5 months at 0° F. without liquid separation; the most stable, for 12 months; and the product of intermediate stability, for 4 months. Since it is anticipated that foods of similar stability at 0° F. will be similarly affected by storage at other temperatures, the results should be applicable to other products.

Various substances such as gelatin, pectin, gums, and Irish-moss extractives are known to have stabilizing properties when added to some foods. Their possible beneficial effect in precooked frozen foods was mentioned by Fitzgerald *(2)* and Tressler and Evers *(12)*. In a previous study *(5)*, these additives were generally not found to be sufficiently effective in improving the stability of the usual wheat flour white sauce held at 10° F. However, the possibility existed that they might be of value when used in the more stable products thickened with waxy rice flour. Another possibility for improving the stability of these foods lay in formula variations. Conflicting opinions have been expressed concerning the effect of the proportion of liquid in products on their texture stability. Woodroof and Atkinson *(14)* reported that thick and thin white sauces were equally satisfactory. Fenton and Darfler *(1)* reported that sauces made from concentrated stock tended to separate less than those made from dilute stock. Tressler and Evers *(12)* reported that lower moisture content tended to give less liquid separation in thickened frozen foods. An exploratory study of stability of cake fillings and puddings thickened with waxy rice flour and egg indicated that slight changes in the relative proportions of thickening agents and liquids might be of considerable importance in increasing stability. This method of increasing texture stability was therefore investigated.

METHODS

Composition of the test products and methods used in their preparation are given in Table 1. The criteria for evaluating stability of the products were (a) liquid separation determined by centrifuging and (b) appearance determined by visual examination. Frozen samples were thawed by placing the cans in a water bath at 77° F. (25° C.) for one hour. Products were stirred to obtain uniform samples for the centrifuge tests. Fifty-gram portions were weighed into 90-ml. plastic centrifuge tubes and centrifuged for 20 minutes on a Sorval Angle Centrifuge at 4500 to 5000 r.p.m. Liquid that separated during centrifuging was filtered through Whatman No. 1 filter paper.

For determining appearance visually, the thawed samples were emptied into petri dishes without stirring. The appearance, whether smooth, grainy, lumpy, curdled, or separated, was noted.

RESULTS AND DISCUSSION

Effect of constant and fluctuating temperatures on texture. The typical pattern of liquid separation as affected by storage conditions is shown for white sauce

TABLE 1

Ingredients and preparation method for the test products

Ingredients	Products		
	Pudding A (Whole egg and waxy rice flour)[1]	Pudding B (Egg yolk and waxy rice flour)[1]	White sauce[2]
	%	%	%
Waxy rice flour	3.0	3.0	4.6
Egg yolk	....	6.0	....
Whole egg	8.0	....	....
Milk	77.8	79.8	90.2
Sugar	10.4	10.4	....
Salt	0.15	0.15	0.6
Vanilla	0.65	0.65	....
Hydrogenated vegetable oil	....	....	4.6

[1] Mix a small amount of cold milk with the egg or egg yolk and a small amount with the dry ingredients. Heat remaining milk to 158° F. (70° C.). Add hot milk to mixture of cold milk and dry ingredients and heat in double boiler with constant stirring for 10 minutes at a mix temperature of 185°–203° F. (85°–96° C.). Add hot mixture slowly with stirring to mixture of egg and cold milk. When egg yolk is used cook in double boiler with constant stirring for 5 minutes at a temperature of 185°–194° F. (85°–90° C.). When whole egg is used, cook in double boiler with constant stirring for 5 minutes at a temperature of 176°–185° F. (80°–85° C.). Add vanilla. Weigh 60 g. into No. 1 short cans, cool, seal and freeze.

[2] Add small amount of cold milk to flour and stir until smooth. Warm remaining milk and fat to 140° F. (60° C.), add to flour and milk mixture and heat with constant stirring. Cook for 1 minute after mixture boils, adding salt during last 20 seconds. Weigh 100 g. into No. 1 short cans, cool, seal, and freeze.

All additives except gelatin were blended with the flour before the milk was added. Gelatin was rehydrated and added at the end of the cooking period.

in Figure 1. For comparative purposes, the time that products can be stored before showing 3% liquid separation was used as an index of stability. This index was selected because products stored long enough to give this amount of separation showed rapidly increas-

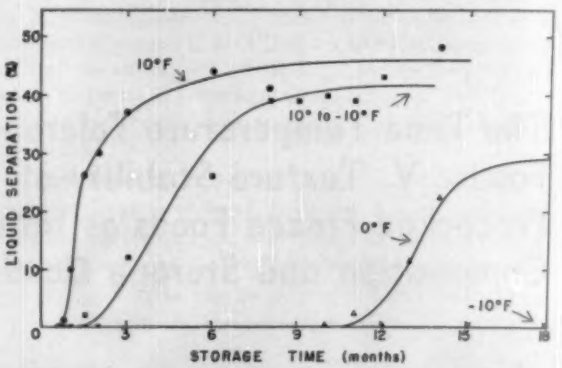

Figure 1. Effect of constant and fluctuating temperatures on storage stability of frozen white sauce thickened with waxy rice flour.

ing separation with further storage. Using this index, the relative stability of the three test products at constant and fluctuating temperatures in the range of 10° to —10° F. was determined (Table 2). The products stored at 0° F. were stable for 6 to 16 times longer than those stored at 10° F. At —10° F. the time without separation increased to considerably over a year for even the least stable product and to over 3 years for the more stable products. Storage of these products at —10° F. is being continued.

Products stored at a constant temperature of 0° F. were stable for 2 to 6 times longer than products stored

TABLE 2

Effect of constant and fluctuating temperatures on thickened precooked frozen foods of differing stability

Product	Storage time resulting in less than 3% liquid separation[1] (months)			
	10° F.	Fluctuating 10° to −10° F.	0° F.	−10° F.
Pudding A	0.25	0.75	1.5	>15
Pudding B	0.5	1.0	4	>36
White sauce	0.75	2	12	>36

[1] Values indicate the longest storage time at which the average liquid separation of all samples was less than 3%. Included were 3 lots of pudding A, 4 of pudding B, and 6 of white sauce held at constant temperatures; and 2, 3, and 4 lots, respectively, at fluctuating temperatures. Several samples showed no separation for considerably longer than the periods given above (e.g., samples of white sauce showed no separation after 2 mo. at 10° F.), but in only one case did a sample show more than 3% separation at any of the above storage times.

at temperatures fluctuating uniformly from 10° to −10° F. in a 24-hour sine wave cycle. This difference in stability would be expected from the extremely high temperature coefficient of the phenomenon of texture change which is evident from the data of Table 2. Fluctuation was less damaging than storage at the highest constant temperature (10° F.). In contrast to these findings on texture of precooked frozen foods, storage at fluctuating temperatures has generally not been found to be more damaging to flavor of frozen foods than storage at the constant mean temperature *(3, 4, 8, 9, 10)*. On the other hand, temperatures fluctuating from −10° to 10° F. resulted in greater moisture loss from frozen turkeys than a constant temperature of 0° F. *(9)*.

As shown by Hicks *(7)* and Schwimmer, Ingraham, and Hughes *(11)*, the stability to be expected for a product subjected to a sine wave temperature fluctuation can be calculated if the temperature coefficient of the reaction is known and is constant over the temperature range used. The data in Table 2 are not considered sufficiently accurate to establish the constancy or a very accurate value of the temperature coefficients. Nevertheless the stabilities calculated from the limited data available are of the same order of magnitude as the observed stabilities for the fluctuating condition. In spite of this fact it is, in our opinion, premature to attempt a decision as to whether or not fluctuation has a specific effect independent of that to be expected from a reaction or change having a constant temperature coefficient.

The temperature of products stored at the fluctuating (−10° to 10° F.) temperature reached within 0.1° F. of the extreme temperatures of the fluctuating range, but lagged behind the air temperature by approximately 35 minutes.

Effect of additives on texture of thickened precooked foods stored at 10° F. The foregoing studies indicated the need for improvement in the texture stability of thickened foods that might be exposed to temperatures above 0° F. during transportation or storage. A study of the effectiveness of a limited number of additives that have been used as stabilizers in other foods was therefore initiated. A comparison was made of the effectiveness of the additives in preventing liquid separation at 10° F. in sauces thickened with either waxy rice flour or wheat flour. The additives exerted a beneficial effect on both types of sauces stored for one month, but at additive concentrations of 0.4 to 1.0%, separation was prevented only in the waxy rice flour sauces (Table 3). Thus, the greatest usefulness of additives at 10° F. occurs when they are added to products having relatively good stability at 0° F.

The white sauce thickened with waxy rice flour and the dessert thickened with egg yolk and waxy rice flour were selected for further testing. They were the most stable sauce and dessert and would, therefore, be expected to benefit most from the additives. Into these products were incorporated gelatin, citrus pectin (slow setting), gums, and Irish-moss extractive.

TABLE 3

Liquid separation in white sauce as affected by thickening agent and additive—1 month at 10° F.

Additive	Concentration	Liquid separation	
		Wheat flour sauce	Waxy rice flour sauce
	%	%	%
None	—	52	10
Citrus pectin	0.4	48	6
Gelatin	0.4	30	0
Gum karaya	0.4	30	8
Gum tragacanth	0.4	17	0
Irish moss extractive	0.4	20	0
Citrus pectin	1.0	36	0
Gelatin	1.0	25	0
Gelatin	1.5	1	0

At a concentration of 0.4% only gum tragacanth was effective in preventing liquid separation in the test products for as long as 2 months. The smooth appearance of the products was lost after 2 weeks, except in the white sauce containing gum tragacanth. The latter product remained smooth for one month.

At a concentration of 1%, citrus pectin prevents liquid separation for 12 months and loss of smooth appearance in both products for 5 months at 10° F. (Tables 4 and 5). Gelatin, gum tragacanth, and Irish-moss extractive prevented liquid separation for 2 months or longer, but loss of smooth appearance was prevented for only 2 months or less. Increase in storage life of these products (determined by maintenance of a smooth appearance) thus varied from no increase to about a 10-fold increase, depending on the additive used. Other additives or higher concentrations of those used here might, of course, have a greater effect.

TABLE 4

Effect of additives on texture stability of custard pudding[1] at 10° F.

Additive	Storage time with 3% or less liquid separation		Storage time without loss of smooth appearance	
	Additive concentration (%)		Additive concentration (%)	
	0.4	1.0	0.4	1.0
	(mo.)		(mo.)	
Citrus pectin	0.5	>12	0.5	5
Gelatin	1	3	0.5	0.5
Gum karaya	<0.5	0.5	<0.5	0.5
Gum tragacanth	2	>11	0.5	2
Irish moss extractive	1	2	<0.5	0.5
No additive	0.5–1.0		0.25–0.5	

[1] Pudding thickened with egg yolk and waxy rice flour.

TABLE 5

Effect of additives on texture stability of white sauce[1] at 10° F.

Additive	Storage time with 3% or less liquid separation		Storage time without loss of smooth appearance	
	Additive concentration (%)		Additive concentration (%)	
	0.4	1.0	0.4	1.0
	(mo.)		(mo.)	
Citrus pectin	0.5	>12	0.5	5
Gelatin	1	3	0.5	2
Gum karaya	0.5	2	0.5	1
Gum tragacanth	2	>3	1	2
Irish moss extractive	0.75	2	<0.5	0.5
No additive	0.75–1.5		0.25–0.5	

[1] Sauce thickened with waxy rice flour.

Effect of formula variations on texture stability of foods thickened with waxy rice flour and egg yolk. A large difference in the texture stability of a pudding-type dessert and a cake filling containing the same 4 basic ingredients led to investigation of the effect of formula variations on stability. Egg yolk, waxy rice flour, milk, and sugar were the basic ingredients of both products. The pudding containing approximately 6% egg yolk, 3% waxy rice flour, 81% milk, and 10% sugar showed liquid separation after 5 months' storage at 0° F. The cake filling containing approximately 4% egg yolk, 6% waxy rice flour, 70% milk, and 20% sugar showed no liquid separation after 12 months at 0° F. To determine the influence of these ingredients on stability, they were combined in varying proportions and placed in frozen storage. The thickening agents, egg yolk and waxy rice flour, always constituted 9 or 10% of the total mixture in order to give products of similar consistency. The ratio of egg to flour varied within this total. The remaining 90 or 91% of the mixture was composed of milk and sugar, varied to give ratios of milk to sugar of approximately 80:10 or 70:20. To accelerate changes, the products were all stored for short periods at 10° F., in addition to the main storage period of 0° F. Differences in appearance were evident after storage for one week at 10° F. plus 6 months at 0° F. (Table 6). After this period the only product showing liquid separation (2%) was the one containing the least waxy rice flour, the most egg yolk, and the most milk. After longer storage (one month at 10° F. plus 6 months at 0° F.) differences in liquid separation were evident (Table 6). All samples containing the higher proportion of milk (80 to 81%) had close to the maximum amounts of separation obtained with this formula, and differences within this group are unimportant. The samples containing the lower proportion of milk had 0 to 10% separation and in general showed greater stability with decrease in egg yolk and increase in waxy rice flour.

It is evident that the stability of products of this type is increased as the egg yolk is replaced by waxy rice flour and as the milk is replaced by sugar.

COMMERCIAL IMPLICATIONS

Laboratory-prepared products rather than commercial products were used in these tests because suitable commercial products were not available. Sauces and gravies used in commercial dinners and pies are difficult to separate from the other ingredients for testing purposes; and the usual egg-and-starch-thickened desserts are not frozen commercially because of the serious texture instability.

The test formulas used contain only the essential ingredients needed to illustrate the behavior of a general type of product under the imposed storage conditions. Improvements in flavor and variations in original consistency can readily be made. The tests reported on the use of additives and on formula variation are limited and are intended primarily to serve as a guide to promising methods of approaching texture stability problems. Sufficient additives have been tested to demonstrate that their use can result in a significant improvement in storage life of the products at 10° F. Other additives or combinations may give even greater improvement.

The relative importance of the two criteria used for evaluating these products will differ for different foods.

TABLE 6

Effect of formula variation on appearance and liquid separation of cooked frozen foods thickened with waxy rice flour and egg yolk

Egg yolk	Waxy rice flour	Appearance[1]		Liquid separation[2]	
		80–81% milk	70–71% milk	80–81% milk	70–71% milk
%	%			%	%
4	5	+	—	31	0
	6	+	—	26	0
5	4	++	—	37	4
	5	++	—	36	2
6	3	+++	—	35	7
	4	++	—	29	10

[1] Storage time: 1 week at 10° F.; 6 mo. at 0° F. Symbols: —, smooth; +, grainy; ++, curdled; +++, curdled and separated.
[2] Storage time: 1 mo. at 10° F.; 6 mo. at 0° F.

The liquid separation test is the easier to apply on a routine basis, and it would be particularly useful in testing a product such as a cake filling. In this type of product, the separation and leakage of the liquid into the cake would be more serious than slight loss of smoothness, which would not be readily observed. In many products, such as sauces and pudding-type desserts, the maintenance of a smooth appearance is essential. Appearance changes are difficult to interpret, because the first slight change that is apparent may not indicate sufficient loss of smoothness to affect commercial acceptability. The results of the tests have been reported in this paper in terms of the time the products can be held without loss of smooth appearance. Thus, they could be held for slightly longer periods before the first change is evident and possibly still longer before the change is important.

SUMMARY AND CONCLUSIONS

This study was undertaken to determine the effect of temperature fluctuations on texture stability of egg- and starch-thickened precooked frozen foods and to devise means of making these foods more stable to adverse temperature conditions. The 3 test products were a white sauce and 2 pudding-type desserts. The thicken-

ing agents included waxy rice flour, egg yolk, and whole egg.

A fluctuating storage temperature ranging from −10° to 10° F. was found to be considerably more damaging to the texture of these foods than a constant temperature of 0° F. This is in contrast to results of flavor studies conducted under similar conditions, since generally no significant difference in flavor stability has been found for samples stored at fluctuating temperatures and the average temperature.

Two general methods were found for improving texture stability of these foods under adverse temperature conditions: the use of additives, such as pectin, gelatin, gums, and Irish-moss extractives, and formula changes involving reduction in the proportion of egg and liquid and increase in the proportion of flour and sugar.

Acknowledgment

The authors wish to acknowledge the assistance of M. F. Pool, who made the product temperature measurements, and the helpful discussions with Hans Lineweaver, W. B. Van Arsdel, S. Schwimmer, and L. L. Ingraham.

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Modifications of the Shear-Press for Electrical Indicating and Recording[a, b]

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(Manuscript received November 6, 1956)

SINCE THE SHEAR-PRESS was introduced in 1950 it has found increasing use in both research and commercial organizations. This has largely resulted from increased emphasis on physical measurements of food quality where previously only organoleptic tests were used. Applications have ranged from evaluating produce varieties to determining quality for cost determination.

Modifications of the original design have been confined to making the mechanism more convenient to operate, transport, and manufacture with an aim toward cost reduction. The present work has been chiefly concerned with the modifications and additions required for electrical indication and recording.

DESCRIPTION OF THE SYSTEM AND MODIFICATIONS

The shear-press used in this work was an improved model of the one described and illustrated initially *(1)*. Force transmitted to the sample was measured by a spring dynamometer. Deflection of this dynamometer is measured by a dial indicator calibrated in pounds force required to cause this deflection.

It was desired to maintain the old system of force measurement to allow direct comparison with data previously obtained. In addition to not furnishing a continuous record of force variation, the previous system was subject to error from several causes. Human error resulted from misreading the dynamometer dial gage scale and from failure to catch the maximum indication of the gage hand. Use of a maximum read-

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pa., May 15, 1957.

[b] This work was conducted at Beltsville, Maryland cooperatively by the Quality Evaluation Section, U.S.D.A. and the Department of Horticulture, University of Maryland.

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ing hand reduces this operator error but further increases error due to friction in the dial gage mechanism.

In addition to reducing these errors, possible additional information about the quality of the sample can be obtained from a recording of force variation as the shear blades pass through the sample. From the area under the curve, the work required can be determined.

Since as few modifications of the existing system as possible were desired, addition of a transducer whose output is an electrical signal proportional to displacement seemed the most desirable solution. Amplification, indication, and recording can then be accomplished by standard methods which are both convenient to use and rugged in nature. Sufficient electrical amplification can be made available to allow selection of convenient ranges for different products, thereby allowing application of the shear-press to a greater variety of products.

By recording the force variation as the sample is tested, a permanent record is produced which can be analyzed at some future time. In this way much of the human error is eliminated with the additional advantage that the test of each sample can be preserved for reference.

Adjustment of the data to compensate for the size of the sample is possible since the base of the force curve is essentially spindle travel through the sample. From the point in this travel at which the sample is contacted, adjustment of the data can be made to allow comparison of samples of different volumes.

While a recorder may not be required for commercial quality control applications, electrical indication remains advantageous. Range changing on the mechanical system necessitates replacing the calibrated dynamometer with another of a different range. Range changing on the electrical system is done electrically; therefore only one dynamometer is required. Chief disadvantage of the electrical system is increased complexity. However, this need not result in greater operating complexity since the number of operating controls can be reduced through good design of the amplifier-indicator.

Initial cost of a single range electrical system would be greater than that of an equivalent mechanical system, but the electrical system would be less expensive when more than one range is required.

CONSTRUCTION

An overall view of the modified shear-press is shown in Figure 1. The recorder and amplifier-indicator are shown to the left of the shear-press.

A block diagram of the system is shown in Figure 2. Except for the electric motor, all items to the left of the line separating electrical and mechanical components were added to the shear-press as a result of recording modifications.

A larger view of the spindle drive cylinder, dynamometer, transducer, and margin marker and chart drive switches are shown in Figure 3. Further construction details of the modifications and additions are shown in Figure 4. Reference is made in the following description to component numbers of this figure.

Shearing of the sample occurs as the shearing blades carried by the piston (1) are propelled through the sample. Force is transmitted through the rod (2) to the dynamometer spring (3). Movement of the end of this spring is proportional to the force on the sample. This motion is transferred to the core (4) of the transducer by a link bearing on the lever (5).

One end of this lever is fixed solidly to the dynamometer, the other rests on a tapered bushing (6). Movement of this bushing along the lever by the adjusting nut (7) moves the core relative to the dynamometer spring, thereby giving a fine mechanical zero adjustment to the system. A similar effect is obtained by rotation of the shell (8), thereby displacing the transformer windings relative to the core and effecting a coarse mechanical zero adjustment.

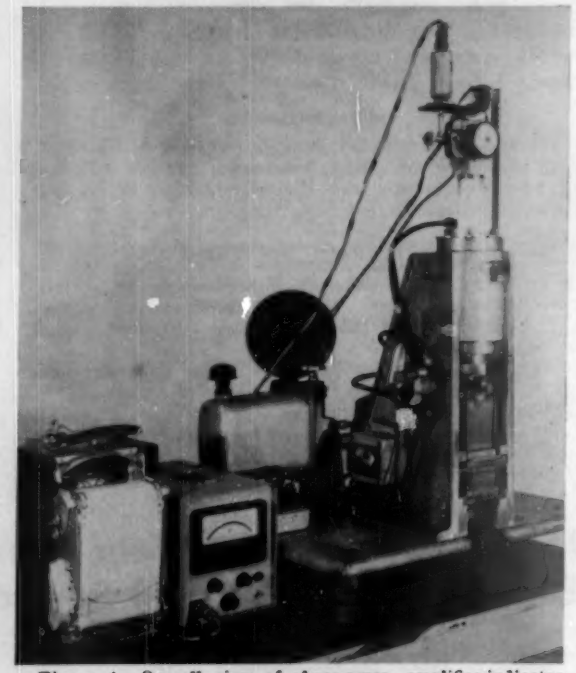

Figure 1. Overall view of shear-press, amplifier-indicator, and recorder.

Since it was desirable to be able to measure forces of a few pounds, it was necessary to incorporate the weight of the shearing head, piston, and rod in the force measuring system. This was done by coupling them to the dynamometer spring through a cone bushing (9) and rubber washer (10). This rubber washer is sufficiently compressed that contact is maintained between the cone bushing and the rod, thereby eliminating a "dead point" as the system goes from tension to compression.

The spherical end of the rod bearing on the cone surface of the cone bushing reduces end friction effects and maintains alignment as the dynamometer spring compresses.

The electrical-mechanical transducer used was a commercial linear variable differential transformer whose

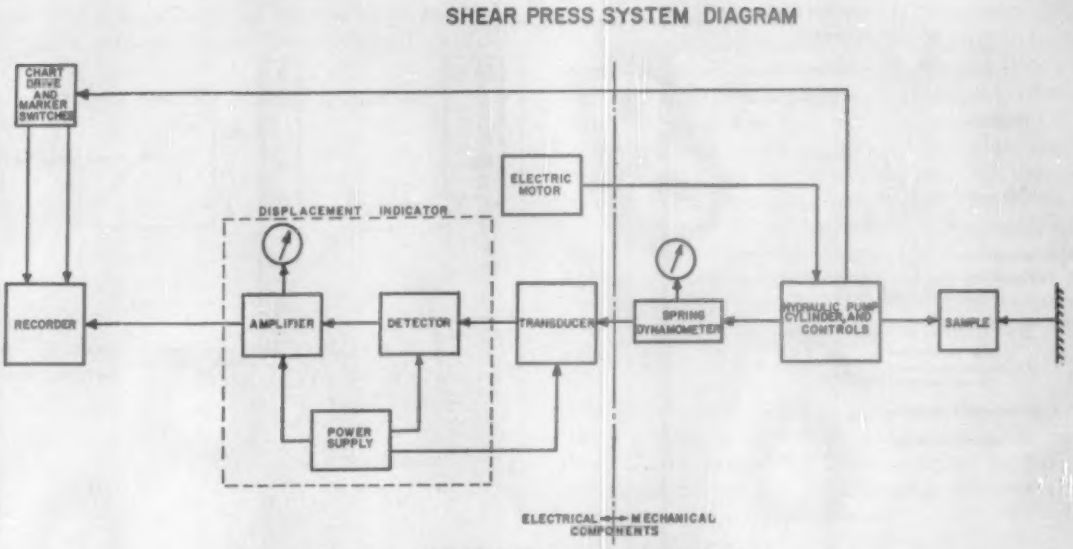

Figure 2. Block diagram of modified shear-press.

electrical output is a signal whose magnitude is linearly proportional to displacement of a small iron core (4). This electrical signal is amplified in the displacement indicator which also supplies the power to excite the transducer. Incorporated with the amplifier system is an attenuator giving three ranges in decade steps. Also included is a calibrating circuit providing means of maintaining instrument calibration as circuit components change with temperature, age, etc.

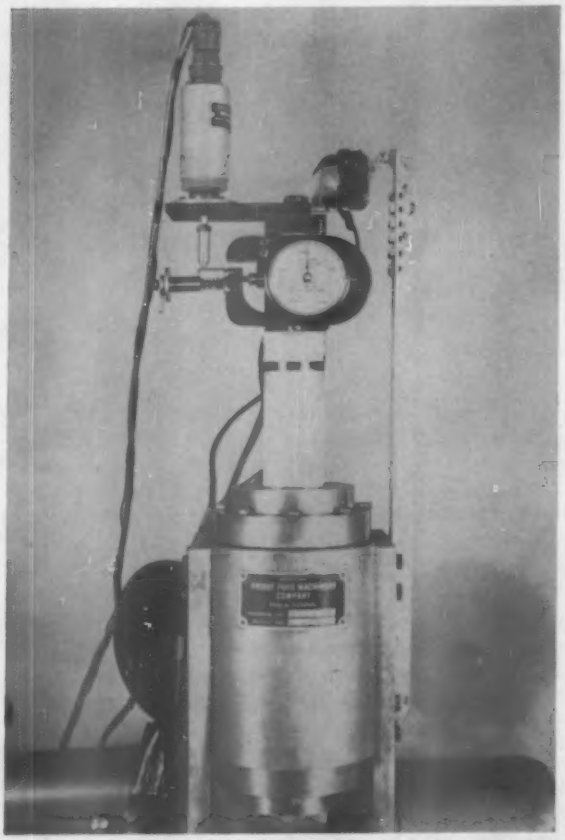

Figure 3. Enlarged view of hydraulic cylinder, transducer, and switches.

The output of the indicator is displayed on a precision panel meter and is also brought to an external recorder jack. The instrument was designed to drive a millivolt servo recorder, or, with additional amplification, a galvanometer recorder of approximately 1400 ohms coil resistance. The displacement indicator was modified according to instructions from the manufacturer to obtain this additional amplification since a galvanometer recorder of this type was available.

To give a reference to the position of the shearing head in the sample box the recorder was equipped with a solenoid margin pen. This solenoid pen is actuated by a switch attached to the moving spindle. As the spindle travels downward, the margin pen switch (13) is tripped by the stationary margin pen switch actuators (14) to give a pip on the chart margin each 0.2 of the total travel through the sample. Use of a hinged actuator eliminates operation of this switch in the reverse direction.

Recorder chart consumption was considerably reduced by controlling the chart drive motor by a second switch immediately behind the margin pen switch. This chart drive switch (15) actuates the chart motor during the downward stroke only, the hinged contactor preventing actuation on the return stroke.

PERFORMANCE OF THE SYSTEM

Utilizing a 2500 lb. capacity dynamometer, the maximum sensitivity of the system is 4 pounds full scale. However, operation at less than maximum sensitivity is desirable since frictional effects in the sample box and on the piston surface reduce the accuracy and reproducibility. Adjustment of the amplifier gain for 50

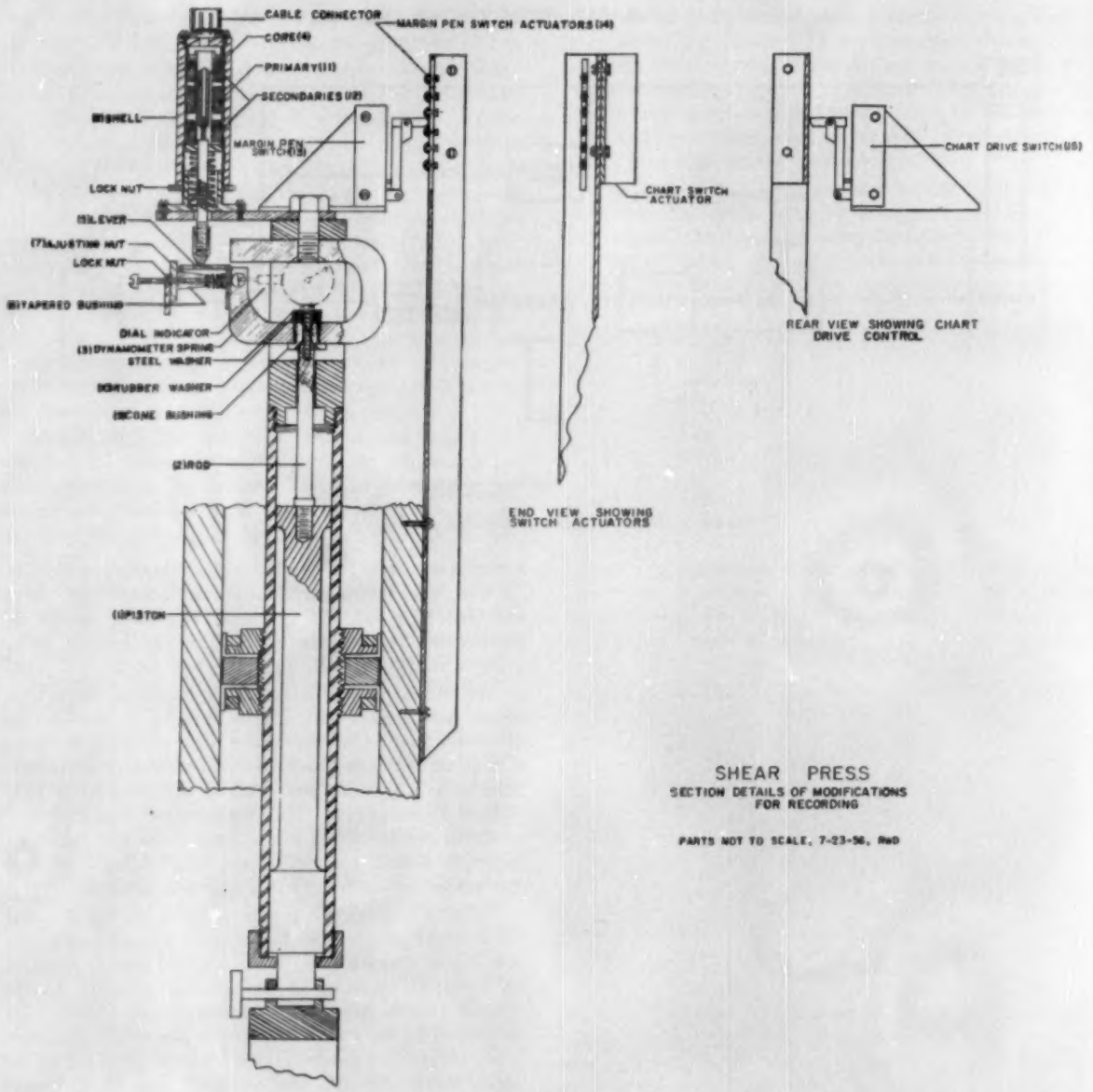

Figure 4. Detail cross-section of cylinder and transducer assembly.

pounds full scale reduces these effects to less than 5% of the full scale value. Absolute accuracy is determined by the accuracy of the calibration. This is easily accomplished by use of the spring dynamometer which is normally in the system.

Linearity is within 1% of the full scale reading. Response time is approximately 0.7 seconds. Resolution and reproducibility are better than 1% of full scale at less than 50 pounds sensitivity. Steady drift of the electrical zero did not exceed 0.8% of full scale per hour. Some mechanical zero drift is present at high sensitivity but this is mostly due to vibration and is of a random nature.

DETAILS OF OPERATION

For stable operation, approximately 30 minutes warm-up is required. The electrical zero of the system is set by the displacement indicator zero control. The operation selector switch is then changed to the sensitivity range being used and the mechanical zero of the transducer is adjusted.

The operation selector switch is next set at calibrate position and the sensitivity control adjusted to full scale deflection. The force required for a full scale deflection can be increased by setting the sensitivity control to less than full scale. For example: setting the sensitivity con-

trol until half scale is indicated requires twice the force of the former setting for a full scale deflection.

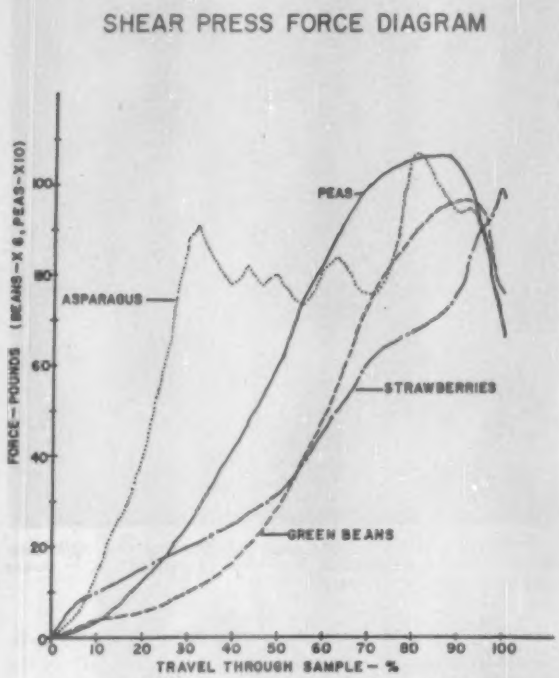

Figure 5. Force diagram of four commodities.

NATURE OF THE DATA OBTAINED

A detailed interpretation of the data will be reported in another paper and is not being attempted at this time. Figure 5 illustrates the type of information obtainable using this system on four different commodities.

The test cell for asparagus consisted of an open box and a single shearing blade while that for the strawberries, green beans and peas was a closed box and ten shearing blades. These curves do not end at zero pounds force since the shear blades are continuing through the bottom grids of the sample box after passing through the sample. This requires considerable force since portions of the material are being carried along.

SUMMARY

Modifications of a shear-press have been described which provide a recording of force variation as the shear blades pass through the sample. Incorporated are range changing and calibrating features greatly increasing usability of the system.

Acknowledgments

The authors acknowledge the cooperation of M. M. Moorhead of Daytronic Corporation on modification of the displacement indicator and of Karl H. Norris and Charles K. Powell for assistance in design and construction of the modified system.

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Notes and Letters

Enumeration and Preliminary Identification of the Microbial Flora of Milk with an Indicator Agar[a]

(Manuscript received October 1, 1956)

Although the standard plate count can be used effectively in the sanitary control of dairy products, it provides little if any information about the nature of the microbial flora and the possible changes it might create in the dairy product. Some added information, however, can be obtained by picking individual colonies from the plates and transferring them into tubes with sterile litmus milk. This procedure, however, is laborious and time consuming. However, it would be very helpful to a control laboratory if the plating medium itself could provide some preliminary information about the nature of the microbial flora and at the same time provide counts comparable with those obtained on a medium recommended by *Standard Methods for the Examination of Dairy Products (1)*.

Recently, Donovan and Vincent *(2)* successfully used a mixture of brom cresol purple and phenol red to differentiate acid and alkali producing colonies. Sterile skimmilk was added to each plate at the time of pouring to detect coagulation and/or hydrolysis of casein.

In the present study the total counts of 50 samples of raw and laboratory-pasteurized milk were determined on both Plate Count Agar *(1)* and a special indicator agar. The milk samples constituted individual farm deliveries collected at a local milk plant. The samples were collected in sterile screw capped jars and were stored under refrigeration. Part of each sample was laboratory-pasteurized in a sterile test tube at 61.7° C. for 30 min. Following pasteurization the samples were cooled rapidly in ice water at 5° C.

The composition of the indicator agar was essentially the same as that of Plate Count Agar *(1)*, with the following exceptions, (a) glucose was replaced with an equal amount of lactose, (b) 120 mg. phenol red, 50 mg.

[a] Technical Article No. 2486 of the Texas Agricultural Experiment Station, College Station.

brom cresol purple, and 4.5 g. of low-heat non-fat dry milk solids were included per liter of medium. The pH of the medium was adjusted to 6.8–7.0. The mixed indicator covers a range from pH 5.2 to 8.4 through yellow (acid), red (neutral), and purple (alkaline). Except for the modification in the plating medium, total counts were made according to *Standard Methods for the Examination of Dairy Products (1)*.

Colonies which showed changes in pH, casein coagulation and/or hydrolysis were selected at random and transferred into tubes with sterile litmus milk and in tubes containing sterile skimmilk with mixed indicator (pH 6.8–7.0). The tubes were incubated at 32° C. for 5 days and were read after 3 and 5 days. The changes in litmus milk and skimmilk with mixed indicator were compared with those obtained on the indicator agar plates.

In Figure 1 is shown an indicator agar plate representing a sample of raw milk. Although differences in color are not apparent, the following changes can be observed, (A) casein coagulation, (B) casein hydrolysis, and (C) casein coagulation and hydrolysis. The total viable counts (geometric means) of 50 samples of raw milk on Plate Count Agar and mixed indicator agar were 33,000 and 32,400; for the 50 samples of pasteurized milk 160 and 140 resp. An analysis of variance indicated that the difference between the counts on the two plating media was not significant. The present technique has the advantage that skimmilk does not have to be added to each plate prior to pouring of the indicator plating medium.

A comparison of the reactions of individual colonies observed on the indicator plates with those in litmus with mixed indicator. On the other hand, a great number of colonies classified as alkali producers failed to show a similar reaction in litmus milk. Donovan and Vincent *(2)* observed a similar phenomenon with alkali producing colonies picked from plates containing raw milk but found close agreement between an alkaline reaction on the indicator plates and in litmus milk with samples of pasteurized milk. In their opinion, this difference is mainly due to spreading alkali producing colonies from raw milk, which might dominate a larger part of the plate.

In the present study only isolated colonies were selected and the discrepancy in behavior of alkali pro-
milk and skimmilk with mixed indicator indicates that colonies which showed acid reaction, casein coagulation, or casein hydrolysis on the indicator agar plates in most cases reacted similarly in litmus milk and skimmilk ducing colonies on indicator plates and in litmus milk cannot be attributed to interference between colonies with different reactions.

It is interesting that colonies classified as alkali producing on indicator agar plates showed in most in-

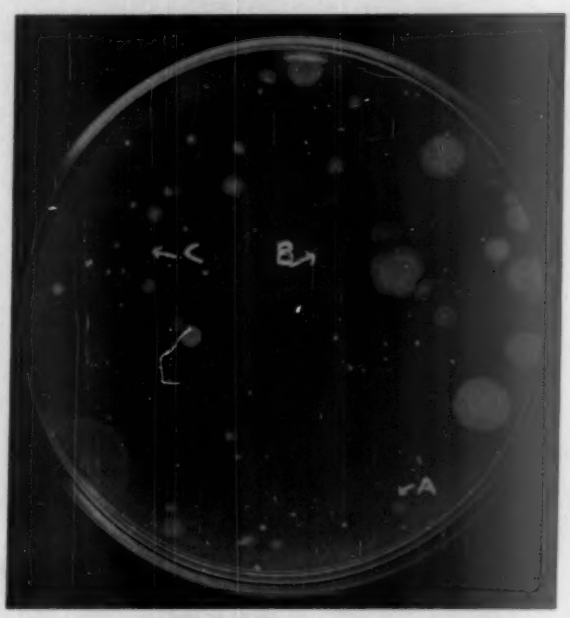

Figure 1. Indicator agar plate representing raw milk sample. A = casein coagulation. B = casein hydrolysis. C = casein coagulation and hydrolysis.

stances a similar reaction in skimmilk with mixed indicator. Subsequent experiments, in which the pH of the skimmilk media was increased slightly by adding dilute NaOH, seemed to indicate that slight increases in pH above neutral are more easily detected in skimmilk with mixed indicator than in litmus milk. This might explain the discrepancy between the behavior of alkali-producing colonies in litmus milk and skimmilk with mixed indicator.

In some cases, especially with plates containing larger numbers of colonies, interference between colonies with different reaction was observed. This problem, however, could be eliminated by reading the plates after 24 hours. A second reading and counting of the individual colonies would follow after incubation for 48 hours.

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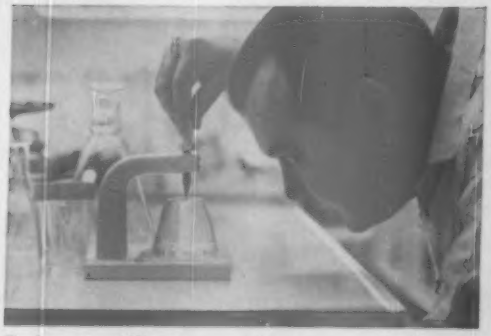

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Write to nearest regional secretary, if within an area covered by a regional section, or to the Executive Secretary of the Institute for an application form and information regarding qualifications and classifications.

One of several steps in reducing thick slabs of steel to the thin-gage strip needed for producing tinplate is cold rolling. Cold reduction, however, tends to make the resulting steel strip hard. In order to regain the steel's workability, it must go through a "softening" process called annealing.

In continuous line annealing, great coils of full hard strip are passed, in single thicknesses, through a series of vertical passes within a furnace. The furnace has heating, holding and cooling zones. Within seconds, the temperature of the steel strip is brought up to a sub-critical temperature near 1200° F. Within three minutes of the time it went into the furnace, the steel is back to just above room temperature. A reducing atmosphere is maintained in both the heating and cooling zones to prevent oxidation—thus maintaining the strip's relatively bright surface throughout. The annealing process assures optimum condition of the steel for further processing. Once annealed, the stresses and hardness caused by cold reduction are relieved.

Exactitude, typified by the annealing process, results in quality tinplate . . . USS Tinplate. This concern for quality has made USS Tinplate a favorite with the canners, manufacturers and processors who supply the market places of the world. United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

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Open new markets with the help of EASTMAN antioxidants

Ever develop a food product which could be given only local distribution—or perhaps couldn't be marketed at all—because of limited stability? If so, it probably contained an oxygen-sensitive ingredient, such as an oil or a fat, which caused the trouble.

Let Eastman help you combat this problem with its complete line of Tenox antioxidants. Our staff of food technologists would welcome the opportunity of working with you on the proper use of these antioxidants. Assisting other food processors in this manner, we have helped send many fine products from the laboratory shelves to the market place.

Since Eastman manufactures the widest range of antioxidants, we have no axe to grind in favor of any one. You can be certain our recommendation will represent the most economical and effective stabilization possible against oxidative deterioration.

For more information about Tenox, write to Eastman Chemical Products, Inc., Kingsport, Tennessee—a subsidiary of Eastman Kodak Company.

Tenox Eastman food-grade antioxidants

FOOD INDUSTRY TOPICS

(Continued from page 32 preceding technical papers

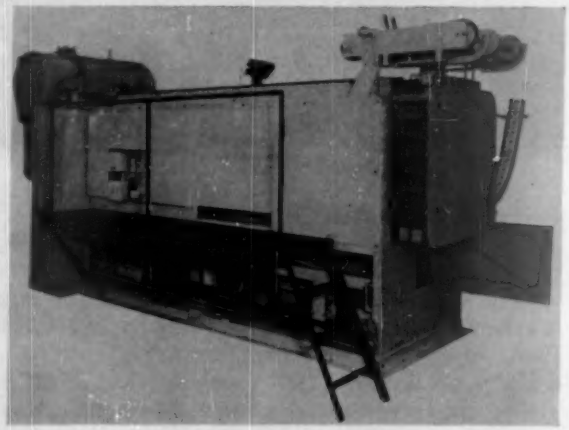
. . . things new under the sun

For the first time in the history of national food promotions, "event packaging" will play an important role next September in the "Food Store Spectacular," which will be conducted in more than 100,000 food stores under the co-sponsorship of the National Association of Retail Grocers and *The Saturday Evening Post*. Atlanta Paper Co., leading supplier of carry-home cartons for the soft drink industry and multiple cartons for the food and related industries, has designed a special multiple carton for cans and bottles that will carry the "Miracle Meals" and "Miracle Marketing" insignia of the special promotion program. The company will offer these cartons in place of its regular cartons to manufacturers who wish to carry the special insignia in food stores during the promotion period, Sept. 12-21.

The "Food Store Spectacular" will climax two years of planning and, according to its sponsors, will be the first and biggest packaged promotion in the history of retail food distribution. A special advertising section of *The Saturday Evening Post*, due on the newsstands Sept. 10, will feature products of the manufacturers participating in the event.

◆ ◆ ◆

A vertical plate freezer, incorporating a new approach to automatic, low-temperature heat transfer, was introduced recently to the food industry. According to the manufacturer, the new freezer operates without the need for an insulated housing, is com-



pletely automatic and clock-timed, and requires less than 100 sq. ft. of non-insulated floor space. Capacities range from 400 to 800 sq. ft. of transfer surface and can be adjusted for varying package sizes in three dimensions.

Package flow through the plates is intermittent, with the intervals timed to equal fractions of the freezing cycle. The flow is vertical, top to bottom, and gravity provides the motion. Feed and discharge into and out of the plates is simultaneous and requires

(Continued on page 54)

How to protect your foods against down-grading by using pure Diamond Crystal Flake Salt

Diamond Crystal *Flake* Salt has the highest uniform purity of any salt made. Ends danger of costly spoilage and "off" flavor from an impure granular salt or rock salt brine. Improves taste and keeping qualities of foods.

DO YOU KNOW what the calcium, magnesium, copper and iron in an impure salt can do to your products?

These impurities form unappetizing scums and discolorations on vegetables. Slow down curing of meat, make it tough and bitter-tasting. Give frozen fish poor texture and fishy taste. Cause oxidative rancidity in foods containing fats and oils.

Today's food market is keen. Competitive. The quality of your product is one of your best sales weapons. Why spoil it with an impure salt?

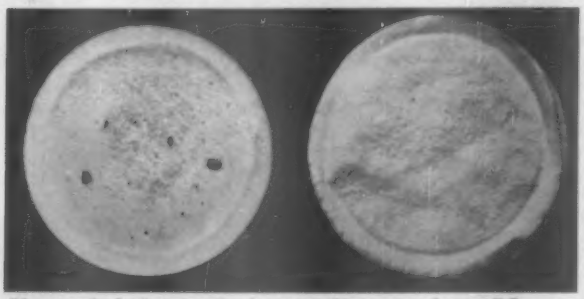
Why flake salt protects quality

Only Diamond Crystal is made by the exclusive Alberger system. This produces flake salt 99.95% pure. An amazing high purity that gives Diamond Crystal *true salt flavor* . . . without the bitter taste imparted by calcium and magnesium compounds, present in less pure salt. By using Diamond Crystal Flake you can *salt to the limit* for optimum flavor.

Diamond Crystal Flake averages less than 1.5 parts per million of copper or iron. Helps prevent oxidative rancidity and off-flavor development.

Are you using the right salt?

The grain size and rate of solubility of salt has an important effect on your product. That's why



Unretouched photograph of actual filter test shows difference in purity and cleanliness between a leading granular, cube-like salt (left); and Diamond Crystal Flake Salt (right).

Notice how impurities in the granular salt used discolored the corn on the left—while pure Diamond Crystal has protected the golden appeal of the corn at right. Which brand do *you* think the housewife would buy again?

Diamond Crystal Flake Salt is precision screened into a wide range of grain sizes to meet the most exacting *individual* requirements of your product.

Send for free analysis

If you are not sure that the salt you're using is suitable for your product, send a sample of it with the coupon below to Diamond Crystal. The salt will be given a careful laboratory test and the results forwarded to you free of charge.

Mail this coupon for free salt analysis

Technical Department FT
Diamond Crystal Salt Co., St. Clair, Michigan

I enclose a sample of the salt I now use. Please have it tested and send me the report free of charge. I would also like information on special Diamond Crystal Salts made for my industry.

Name_____

Company_____

Product_____

Address_____

City_____ State_____

SELECTED ABSTRACTS . . .

Compiled by H. A. Campbell

ANALYTICAL METHODS

Microdesalter for qualitative paper chromatography of amino acids.

ZWEIG, G., AND HOOD, S. L. (Charles F. Kettering Foundation, Yellow Springs, Ohio). *Anal. Chem., 29,* 438-41 (1957).

The advantages of this technique are the speed of the operation and the small size of the sample required for desalting.

Characterization of long-chain fatty acids by infrared spectroscopy.

MEIKLEJOHN, R. A., MEYER, R. J., ARONOVIC, S. M., SCHUETTE, H. A., AND MELOCH, V. W. (Univ. of Wisconsin, Madison. *Anal. Chem., 29,* 329-33 (1957).

Long-chain fatty acids may be identified by infrared spectrophotometry of the solid compds. from their band progressions in the 7.43- to 8.47-micron region using the KBr disk technique. Number of bands in the progression is approx. half the no. of C atoms in the chain. Infrared spectra of high purity fatty acids, C_{10} to C_{20} are given.

The separation of the C_7-C_{12} fatty acids by reversed-phase partition chromatography.

WITTENBERG, J. B. (Yeshiva Univ., N. Y. 61). *Biochem. J., 65,* 42-5 (1957).

The sepn. of γ-hexanoic, γ-octanoic, γ-decanoic and dodecanoic acids is illustrated. The terpene acid, geranic acid, is sepd. from decanoic acid with each of the solvent mixts. described.

Determination of solvent vapors in air. I. Cyclohexane.

KOBAYASHI, Y. (Yokohama Univ.) *J. Soc. Org. Synthet. Chem., Japan, 12,* 63-6 (1954); *Chem. Abstr., 51,* 952f (1957).

Anhydrous chromic acid and H_2SO_4 absorbed on orange silica-gel particles is used as a detector. Thirty ml. of air is passed through the detector tube in 150 sec. The concn. of cyclohexane gas is detd. from the length of greenish black color in the tube. The effective range is 0.01-100 mg./l. The error is $< \pm 5\%$.

Determination of distinctive added organic materials of whisky. VI. Spectrophotometric determination of citric acid.

PRO, M. J., AND NELSON, R. A. (Alcohol and Tobacco Tax Division Lab., Internal Revenue Service, Washington, D. C.). *J. Assoc. Official Agr. Chemists, 39,* 952-6 (1956).

A micro-spectrophotometric method for the detn. of citric acid in whisky has been described. The procedure is accurate, rapid, and specific, and is especially adaptable to the measurement of a few micrograms of citric acid.

Determination of traces of ketone in a carbinol by differential infrared analysis.

WASHBURN, W. H., AND SCHESKE, F. A. (Abbott Labs., North Chicago, Ill.). *Anal. Chem., 29,* 346-7 (1957).

Small amts. of ketone can be simply and precisely detd. by differential infrared analysis using a double-beam instrument. By comparison of the test sample with the pure major constituent at the 5.93-micron absorption band, ketones in the range from 0.1 to 1.0% may be detd. with an accuracy of $\pm$ 0.02%.

Molecular weight determination of components by gas-phase chromatography.

LIBERTI, A., CONTI, L., AND CRESCENZI, V. (Univ. of Rome, Italy). *Nature, 178,* 1067-8 (1956).

The gas-density balance app. developed by Martin and James for detection and estn. of components in gas-phase chromatography is used for a rapid process for evaluating the mol. wts. of single components.

Schlieren method for mass determination in microscopic dimensions.

MEYER-ARENDT, J. R. (Ohio State Univ., Columbus). *Rev. Sci. Instr., 28,* 28-9 (1957).

The paper discusses the principle and gives some formulas that can be used for computing from schlieren effects the refractive index, the mass concn., and the anhydrous mass of microscopic particles like cells or cell constituents.

A new detector for vapor phase chromatography.

HARLEY, J., AND PRETORIUS, V. (Univ. of Pretoria, Union of S. Africa). *Nature, 178,* 1244 (1956).

In vapor phase chromatography a thermal conductivity cell permits the estn. of amts. of material at the min. of the order of 10^{-9} mole. Depending upon the fact, that voltage across a normal gaseous discharge is a function of the type of gas used, a detector has been designed to detect 10^{-12} mole.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

The antibacterial action of some basic amino acid copolymers.

BICHOWSKY-SLOMNICKI, L., BERGER, A., KURTZ, J., AND KATCHALSKI, E. (The Weizmann Inst. of Sci., Rehovoth, Israel). *Arch. Biochem. and Biophys., 65,* 400-13 (1956).

The data obtained indicate that, in copolymers investigated, the presence of a basic amino acid residue is required for antibacterial activity, while the leucine residue greatly enhances bactericidal properties.

Reaction of aldoses with amino compounds.

HAUGAARD, G., AND TUMERMAN, L. (Natl. Dairy Research Labs., Inc., Oakdale, Long Island, N. Y.). *Arch. Biochem. and Biophys., 65,* 86-92 (1956).

A soly. method for measuring aldose-amino interaction has been extended to the study of the kinetics of glucose condensation with leucylglycine, β-lactoglobulin, and ρ-aminobenzoic acid. The primary reaction rate and secondary reversible and irreversible decompn. of the resp. Schiff bases have been characterized and their reaction const. calcd. These compds. were found to react more rapidly than the common aliphatic amino acids, at pH values within the biol. range, and this form of aldose-amino condensation may therefore have physiol. significance.

Acetate as a precursor of amino acids of casein in the intact dairy cow.

BLACK, A. L., KLEIBER, M., SMITH, A. H., AND STEWART, D. N. (Univ. of California, Davis). *Biochim. et Biophys. Acta, 23,* 54-9 (1957).

The paper reports on a more extensive study of the relationship between acetate and amino acids in the intact cow. It was found that C from acetate was transferred most efficiently to glutamic acid. The differences between glucose and acetate as precursors of amino acids are discussed.

The degradation of heparin by bacterial enzymes. I. Adaptation and lyophilized cells.

PAYZA, N. A., AND KORN, E. D. (Natl. Inst. of Health, Bethesda, Md.). *J. Biol. Chem., 223,* 853-8 (1956).

The paper describes the isolation of a soil bacterium which is able to use heparin as its sole source of C, N, and S, some expts. on the adaptation of the bacteria to heparin, and the characteristics of the degradation of heparin by lyophilized cells.

The degradation of heparin by bacterial enzymes. II. Acetone powder extracts.

KORN, E. D., AND PAYZA, N. (Natl. Inst. of Health, Bethesda, Md.). *J. Biol. Chem., 223,* 859-64 (1956).

The degradation of heparin by exts. of acetone powders of *Flavobacterium heparinum* was studied. It has been found that the ext. contains a sulfamidase, a sulfesterase, and at least one glycosidase which, together, catalyze an extensive cleavage of heparin.

An improvement of the hydrazine method for determination of C-terminal amino acids.

BRADBURY, J. H. (Commonwealth Sci. and Ind. Research Organization, Geelong, Victoria). *Nature, 178,* 912–13 (1956).

The addn. of hydrazine sulfate as a catalyst makes it possible to decompose peptides under mild conditions so that all the common amino acids can be recovered in fair yield.

On the mechanism of enzyme action. LXI. The self digestion of trypsin, calcium-trypsin and acetyltrypsin.

NORD, F. F., BIER, M., AND TERMINIELLO, L. (Fordham Univ., New York). *Arch. Biochem and Biophys., 65,* 120–31 (1956).

The self-digestion of trypsin proceeds by second-order kinetics. Acetylation stabilizes the enzyme by reducing the self-digestion to a first-order reaction. The addn. of Ca ions to trypsin also stabilizes the enzyme, the order of reaction being intermediate, i.e., 1.5. The protective effects of acetylation and Ca ions are additive, and acetyltrypsin in the presence of Ca ions resists inactivation at 25° C. and pH 8.5. In the initial stages of self-digestion, trypsin liberates the lowest no. of free amino groups per mole of enzyme inactivated. This no. increases with Ca-trypsin and even more so with acetyl-trypsin. The finding suggests the presence of an enzymatically active degradation product of the native cryst. trypsin.

Analytical use of the protein-dissolving effect of urea.

CHRISTENSEN, L. K. (Gentofte Hosp., Copenhagen, Denmark). *Arch. Biochem. and Biophys., 65,* 340–6 (1956).

The capacity of strong urea solns. to dissolve protein ppts. may be utilized for detn. of protein concns. by ultraviolet absorbancy measurement since urea itself has a very low absorption at the wavelength employed. This can serve as a basis for methods of detg. peptic or tryptic hydrolysis. These procedures are useful for detn. of proteolytic activity of media with high contents of extraneous protein or of nonprotein substances having a high ultraviolet absorbancy.

Phytin elimination in soybean protein isolation.

SMITH, A. K., AND RACKIS, J. J. (Northern Utilization Research Branch, Peoria, Ill.). *J. Am. Chem. Soc., 79,* 633–7 (1957).

In extg. proteins from the meal, the phytin reacts with the proteins to form complex products of varying compn. It has been demonstrated that phytin can be eliminated from H_2O ext. of soybean meal by a combination of dialysis and treatment with the anionic-exchange resin Dowex-1-X10. Electrophoretic studies have shown that one minor component of the acid-pptd. protein-phytin reaction product, and two other minor components are affected by the presence of phytin.

A method for the specific proteolytic cleavage of protein chains.

Use

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Proteolytic Enzymes to hydrolyze protein

RHOZYME purified food-grade enzymes serve as valuable aids in processing a wide variety of protein-containing material. If you want to make meats tender but not mushy, modify whey protein for cheese spreads, or prepare protein hydrolyzates, RHOZYME natural enzymes are efficient and economical. The food engineer will also find RHOZYME enzymes useful in processing a wide variety of proteinaceous wastes, either to convert them to useful products or to dispose of them economically.

Supplied as dry powders with excellent storage stability, RHOZYME enzymes are carefully standardized to give uniform, reliable performance.

If you want to improve the processing of protein we will be glad to show you how the *specific* and *controlled* action of RHOZYME enzymes can help. Write Dept. SP for full information.

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ANFINSEN, C. B., SELA, M., AND TRITCH, H. (U. S. Dept. of Health, Education and Welfare, Bethesda, Md.). *Arch. Biochem. and Biophys., 65,* 156–63 (1956).

Oxidized ribonuclease was reacted with carbobenzoxychloride, the carbobenzoxylated protein obtained was digested with trypsin, and the carbobenzoxy groups were removed from the tryptic digest by means of anhydrous hydrogen bromide. The analysis of the tryptic digest before and after decarbobenzoxylation showed that four new end groups were liberated during trypsin digestion, in accordance with the presence in ribonuclease of 4 arginine residues. The peptide fragments formed were sepd. by high-voltage paper electrophoresis. The expts. described suggest that this method may be of general use as a preliminary step in the detn. of the sequential arrangement of amino acid residues in peptidic chains.

Observations on the effect of urea on crystalline pepsin.

PERLMANN, G. E. (Rockefeller Inst. for Med. Research, N. Y.). *Arch. Biochem. and Biophys., 65,* 210–17 (1956).

A marked loss of the enzymic activity occurs if pepsin is kept in urea contg. buffers at temps. above 20° C. The rate of the inactivation process is a function of the urea concn., pH, and the compn. of the solvent. The loss of activity, moreover, is accompanied by changes in the ultraviolet absorption of the protein, in the electrophoretic properties, and in its soly. in trichloroacetic acid.

A new antagonist of thiamine.

ULBRICHT, T. L. V. (Yale Univ. Sch. of Med., New Haven, Conn.). *Nature, 178,* 913–14 (1956).

2-Methylthiopyrimidine instead of replacing the amine as a growth factor was found to be an inhibiting antagonist of thiamine in *E. coli.*

Biochemical aspects of atherosclerosis.

ANFINSEN, C. B., JR. (Natl. Inst. of Health, Bethesda, Md.). *Federation Proc., 15,* 894–9 (1956).

A review presenting some of the approaches made on atherosclerosis. Particular emphasis was placed on the control, production and transport of α- and β-lipoproteins in body fluids.

Nutrients in Central American beans.

TANDON, O. B., BRESAANI, R., SCRIMSHAW, N. S., AND LE BEAU, F. (Inst. of Nutrition of Central America and Panama). *J. Agr. Food Chem., 5,* 137–42 (1957).

The factors influencing protein, methionine, lysine, and tryptophan content of 25 varieties were studied. Niacin, thiamine, and riboflavin were also detd. Over-all differences in N and tryptophan content among varieties and between localities were highly significant. The fertility of the land significantly alters the yield and riboflavin content of the kidney bean, but the content of N, methionine, lysine, tryptophan, niacin, and thiamine is not detectably affected by fertility differences.

MICROBIOLOGY

Analytical microbiology. I. The test organism.

GAVIN, J. J. (Food Research Labs., Inc., Long Island City, N. Y.). *Appl. Microbiol., 4,* 323–9 (1956).

A series of papers which deals with the theoretical aspects of analytical microbiology which are common to all types of methods. All methods used for microbiological assay have been classified in one of the following categories: (1) diffusion methods; (2) turbidimetric methods; (3) metabolic response methods; (4) gravimetric methods.

Inhibition of bacterial growth by selective interference with the passage of basic amino acids into the cell.

MANDELSTAM, J. (Natl. Inst. Med. Research, London, Engl.). *Biochim. et Biophys. Acta, 22,* 324–8 (1956).

The effect of aliphatic diamines upon growth of bacteria has been compared with their effect upon the passage of lysine and arginine across the cell wall. The results suggest that the diamines inhibit growth by retarding the entry of the amino acids into the cells.

Incidence and kinds of microorganisms associated with commercially dressed poultry.

WALKER, H. W., AND AYRES, J. C. (Iowa State Coll., Ames). *Appl. Microbiol., 4,* 345–9 (1956).

Storage of poultry at 4.4° C. in polyethylene bags generally resulted in spoilage in from 4 to 6 days and was assocd. with organisms with characteristics of the *Pseudomonas-Achromobacter* group.

The isolation of pathogenic bacteria from used emulsion oils.

TANT, C. O., AND BENNETT, E. O. (Univ. of Houston, Texas). *Appl. Microbiol., 4,* 332–8 (1956).

A new technique for isolation of pathogenic bacteria from used emulsion oils is described. The significance of this investigation from the economic, industrial-hygiene, and public-health standpoints is discussed.

Effect of curing ingredients and procedures on the survival and growth of staphylococci in and on cured meats.

LECHOWICH, R. V., EVANS, J. B., AND NIVEN, C. F. (Univ. of Chicago, Ill.). *Appl. Microbiol., 4,* 360-5 (1956).

Food-poisoning staphylococci were able to grow vigorously in ground pork muscle contg. any combination of curing ingredients that is permissible and palatable. However, if the pH of the meat was lowered to 4.8, anaerobic growth of the staphylococci was prevented even in the absence of nitrite. Most staphylococci injected into hams survived a normal curing operation until the smoking operation. Heating in a smokehouse to an internal temp. of 137° F. killed all surviving staphylococci. Heating in a smokehouse at 120° F. for 48 hr. slowly killed the staphylococci in the interior of the ham, but they occasionally multiplied on the surface. There was no evidence of any staphylococcal multiplication in the interior of the hams at any time during this heating period.

Cellular organization in relation to function.

MUDD, S. (Dept. of Microbiology, Univ. of Pennsylvania). *Bacteriol. Revs., 20,* 268–71 (1956).

The localization of the enzymes catalyzing the reactions of the tricarboxylic acid cycle in *Azotobacter vinelandii* has been ascertained by use of this quant. approach to bacterial cytochemistry. It was observed that cell lysis, by grinding with alumina, resulted in the recovery of all of the succinic, malic, and cytochrome oxidase activities in the particulate fractions, whereas exts. prepd. in the sonic oscillator contained a large proportion of the oxidases in a nonsedimentable form. This suggests that granule rupture may be an important consideration in studies of enzyme localization.

Symposium on Enterobacteriaceae of medical significance: isolation, identification, and pathogenic potentialities.

NETER, E. (Univ. of Buffalo, New York). *Bacteriol. Revs., 20,* 272–3 (1956).

The problem of *salmonellae* and salmonellosis was surveyed by Dr. Shaughnessy. He pointed out that there are now approx. 350 serotypes, which are widely distributed in the animal kingdom. Among the types most commonly isolated from man in the United States are *Salmonella typhimurium, S. newport, S. oranienburg, S. montevideo, S. bareilly, S. anatum,* and *S. panama.*

Symposium on petroleum microbiology.

DAVIS, J. B. (Magnolia Petroleum Co., Dallas, Texas). *Bacteriol. Revs., 20,* 261–4 (1956).

A review on microbiological corrosion and its relation to oil production. The mechanisms by which microorganisms affect corrosion were briefly discussed.

Symposium on industrial fermentations.

SAUDEK, E. C. (The Upjohn Co., Kalamazoo, Mich.). *Bacteriol. Revs., 20,* 279–81 (1956).

Symposium was presented to show some of the necessary studies and applications involved in most industrial type fermentations, particularly the antibiotic-producing variety.

NUTRITION

Some effects of prolonged undernutrition on carbohydrate metabolism in rats.

(Continued on page 46)

PROVERB PRATTLE

"Ignorance is bliss"

From Thomas Gray's "Ode on a Distant Prospect of Eton College." The complete quotation is: "Where ignorance is bliss, 'tis folly to be wise."

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Position_____

Company_____

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City_____ Zone_____ State_____

(Continued from page 44)

HALMI, N. S., AND SPIRTOS, B. N. (State Univ. of Iowa, Iowa City). *Am. J. Physiol., 187,* 432–6 (1956).

Underfed rats were fasted 24 hrs., then fed 5 g./100 g. body wt. and tested 8 hrs. later. These rats exhibited a) no greater insulin sensitivity, b) lower blood sugar levels and c) a smaller rise in liver glycogen concn. than similarly treated ad libitum-fed animals. Intestinal absorption of glucose was not diminished in the under-nourished rats.

Nutrition and atherosclerosis.

KATZ, L. N., STAMLER, J., AND PICK, R. (Michael Reese Hospital, Chicago, Illinois). *Federation Proc., 15,* 885–93 (1956).

Evidence for the relationship of atherosclerosis to nutrition is presented. Atherosclerosis was shown to be a problem of essentially cholesterol-lipid-lipoprotein metabolism in which nutrition plays a key role.

Age factor and high-fat diets in the evolution of osteoarthritis in mice.

SILBERBERG, M., AND SILBERBERG, R. (Washington University, Sch. of Med., St. Louis). *J. Gerontol., 12,* 9–13 (1957).

In male mice of strain C57BL, feeding of a diet enriched 25% lard increased the incidence and accelerated the progress of degenerative joint disease as compared to conditions in stock-fed control animals. Consumption of the high-fat ration for a limited length of time had less injurious effects on the articulations than prolonged consumption of the same diet.

Muscle and liver glycogen of mouse strains susceptible or resistant to nutritionally induced obesity.

LYON, J. B., AND FENTON, P. F. (Emory Univ., Ga.). *Am. J. Physiol., 187,* 415–16 (1956).

The observations reported indicate that low muscle and high liver glycogen levels occur in mouse strains susceptible to nutritional obesity.

Feeding studies on vitamin- and mineral-fortified whole milk.

TEPLY, L. J., PRIER, R. F., AND SCOTT, H. T. (Wisconsin Alumni Research Foundation, Madison). *Food Research, 21,* 671–9 (1956).

Rats were fed milk diets supplemented with up to 4X the normal level of vitamins and minerals present in fortified whole milk. No deleterious effects due to the supplements were observed.

Vitamin B_{12} serum concentrations in 528 apparently healthy human subjects of ages 12-94.

GAFFNEY, G. W., HOBONICK, A., OKUDA, K., MEIER, P., CHOW, B. F., AND SHOCK, N. W. (Natl. Inst. of Health, Bethesda, Md.). *J. Gerontol., 12,* 32–8 (1957).

Assays of vitamin B_{12} concn. by growth responses of *Lactobacillus leichmannii* were made in fasting serum specimens from 528 persons of ages 12–94, of whom 419 were males. Regression of serum B_{12} level on age was highly significant for each of the groups studied. It is suggested that if dietary conditions per se play a significant role in the age-wise decrease in serum B_{12} in the groups studied, they do so in consequence of an age-dependent alteration in the selection of foods by the subjects themselves.

Effect of supplementing soybean proteins with lysine and other amino acids.

BLOCK, R. J., ANDERSON, D. W., HOWARD, H. W., AND BAUER, C. D. (Prescription Products Div., Borden Co., N. Y.). *Am. J. Diseases Children, 92,* 126–30 (1956); *Nutrition Abstr. & Revs., 27,* No. 861 (1957).

Dietary aspects.

STARE, F. J. (Harvard School of Public Health, Boston, Mass.). *Federation Proc., 15,* 900–4 (1956).

A review presenting incidence of atherosclerosis with reference to type of diet.

PHYSIOLOGY AND MEDICINE

Conference on tissue culture.

Science, 125, 30+ (1956).

Scientists from different countries presented a fascinating work in which animal organs such as kidney were broken down into a brew of single cells by partial digestion, stopping short of killing the cells, and then recombined so that, for example, a kidney made up of mixed chicken and mouse cells yet capable of at least partial function, was formed. This, together with the work on cultivation of whole organs provides for basis for the ultimate provision of "spare parts" for damaged bodies.

ENGINEERING AND PLANT EQUIPMENT

New type of mill for refined chemicals.

TANNER, H. G. (Fort Detrick, Md.). *Ind. Eng. Chem., 49,* 170–3 (1957).

A description of a mill for producing powders in the 1 to 5 microns range. Mill apparently works by spinning particles at such a high rate that they fail in tension due to high centrifugal force.

Directed interesterification of lard.

PLACEK, C., AND HOLMAN, G. W. (Procter & Gamble Co., Cincinnati, Ohio). *Ind. Eng. Chem., 49,* 162 (1957).

Describes the production of "quality" shortening from lard by directed rearrangement of the fatty acids of the glycerides to yield a product of broad plastic range and improved crystal habits. Discusses the chemistry of the reaction development of the process and factory application.

FOOD AND FOOD TECHNOLOGY

CEREALS AND GRAINS

Artificial drying and rehydration of popcorn and their effects on popping expansion.

HUELSEN, W. A., AND BEMIS, W. P. *Univ. Illinois Agric. Expt. Sta. Bull. 593,* 68 pp. (1955); *Food Sci. Abstr., 28,* No. 2452 (1956).

In this 4-year investigation of the conditioning of popcorn to secure max. popping expansion, the pilot-plant bin drier used had instruments to record the temp. of the corn, and the wet-and dry-bulb temps. of the incoming and outgoing air. The trade standard popping expansion of 30 vols. or more was obtained with the variety Purdue 202 in the range of 9 to 15% moisture content, and with Purdue 32 and Iopop 6 in the range 10 to 15%, whereas Illinois 52 had a range of only 11 to 14%, and Iopop 5 barely reached 30 vols. at about 13% moisture. When the corn was artificially dried, and rehydrated to 13% moisture, expansion was less if the corn had been harvested at moisture contents above 25%. Artificial drying had a slight adverse effect on popping expansion, even when unheated air was used, and the damage was somewhat greater with heated air in the range 110° to 130° F. (43° to 54° C.). Damage was not consistently related to drying temp., but appeared to be correlated with rate of drying. The popping expansion of corn dried on the cob was much less affected than that of corn dried after shelling, no doubt because of the difference in rate of drying. Chilling the corn at 35° F. (2° C.) before drying had no adverse effect on popping expansion, nor had freezing at —10° F. (—23° C.), except with corn contg. more than 20% of moisture.

COCONUTS

γ-Amino-butyric acid and other free amino-acids in the coconut.

BAPTIST, N. G. (Univ. of Ceylon). *Nature, 178,* 1403-4 (1956).

γ-Amino-butyric acid has been isolated from the liquid inside the mature coconut.

COFFEE AND TEA

Principal constituents of tea leaf.

KEEGEL, E. L. (Tea Research Inst. of Ceylon, St. Coombs, Ceylon). *Coffee & Tea Ind., 80* (2), 69 (1957).

The principal constituents of the tea leaf are oxidizable matter, pectins, caffeine and aromatics. The oxidizable matter (35-40% of dry leaf) is preferably called tea catechins instead of the objectionable term tannins.

FATS AND OILS

The function of phospholipids.

BEVERIDGE, J. M. R. (Queen's Univ., Kingston, Ontario, Canada). *Can. J. Biochem. & Physiol., 34,* 361-71 (1956); *Fats, Oils, Det. A:165* (1956).

The three principal roles of the phospholipids are: 1. As intermediates in the resynthesis of triglycerides during the absorption of fat. 2. As vehicles for the transport of neutral fat in the form of

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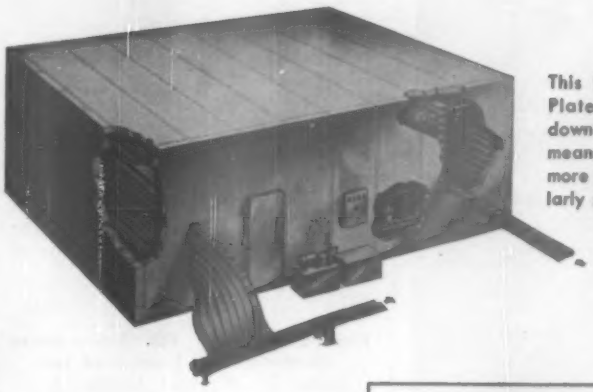

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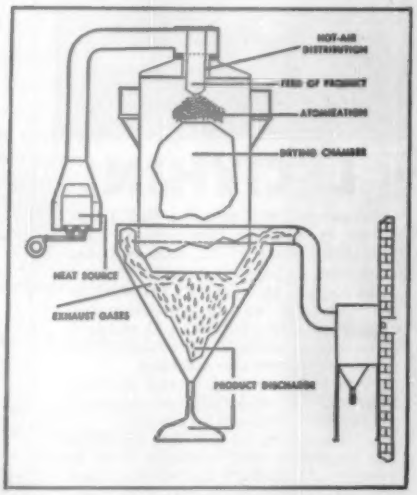

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fatty acids. 3. As facilitating agents of the oxidation of fatty acids.

FEEDSTUFFS

Feed from sewage. III. Dried activated sewage sludge as a nitrogen source for sheep.

HACKLER, L. R., NEUMANN, A. L., AND JOHNSON, B. C. (Univ. of Illinois, Urbana). *J. Animal Sci., 16,* 125–9 (1957).

A ration in which 18% of the N was supplied as dried activated sewage sludge was found equal, as measured by N retention, to soybean oil meal and urea-contg. rations of similar crude protein content (11–12%).

GELATIN

Color reactions of gelatins treated with nitrous acid.

VENET, A. M., AND POURADIER, J. (Kodak-Pathe, Vincennes, France). *Sci. et inds. phot., 27,* 417–22 (1956); *Chem. Abstr., 51,* 895d (1957).

The coloration formed by reaction of HNO_2 with gelatin is due primarily to tyrosine in gelatin. Variations of the color depend on the nature and concn. of mineral impurities in gelatin.

MEAT

Freeze-dried meat. III. Non-oxidative deterioration of freeze-dried beef.

REGIER, L. W., AND TAPPEL, A. L. (Univ. California, Davis). *Food Research, 21,* 630–49 (1956).

Results of phys. and chem. measurements made on samples stored in N_2 at controlled temp. and H_2O content are reported. Browning is the major deteriorative reaction. Although rate of deterioration is increased with increasing moisture level, essentially complete removal of H_2O does not eliminate storage deterioration.

Proteolytic enzyme activity in irradiation-sterilized meat.

DRAKE, M. P., GIFFEE, J. W., RYER, R., AND HARRIMAN, H. (Food and Container Inst. for the Armed Forces, Chicago). *Science, 125,* 23 (1957).

Tyrosine crystals in the storage of irradiation-sterilized raw meat is indicative that a general proteolysis occurs in irradiated meat samples. The necessity for inactivation of the proteolytic enzymes is indicated, therefore, if irradiation-sterilized meat is to become an acceptable food product.

MILK AND MILK PRODUCTS

Nutritive value of the proteins of stored instant nonfat dry milk.

HODSON, A. Z., AND MILLER, C. B. (Pet Milk Co., Greenville, Illinois). *Food Technol., 11,* 89–92 (1957).

The protein efficiencies for net growth and the lysine content of pasteurized milk and of instant nonfat dry milk stored under favorable conditions are similar.

ORGANIC CHEMISTRY

A method of promoting water-forming organic reactions.

KOLLONITSCH, J., AND VITA, J. (Research Inst. for the Pharmaceutical Ind., Rottenbiller, Budapest). *Nature, 178,* 1307 (1956).

The use of boric acid esters has been found to promote esterifications of acids, amino acids, peptides, ketols and acetals.

PHYSICAL RESEARCH

Resistance of flow in Teflon and brass tubes.

BROCKMAN, M. R. *J. Research NBS, 58,* 51–60 (1957).

The resistance measurements detd. for extruded Teflon tubing were compared with those of smooth-drawn brass tubing. The coeffs. were so similar that it can be said that no slip flow exists for H_2O flowing through Teflon tubing.

STATISTICS

Factorial experiments help to improve your food.

YOUDEN, W. J. (Natl. Bureau of Standards). *Ind. Eng. Chem., 49* (2), 85–6A (1957).

A three factor expt. is described and the details of the analyses presented in an easily understandable manner. It is shown that misleading conclusions might be reached without careful analysis. The data represents the results of an actual expt. conducted at General Food's Central Laboratories.

The principles of experimental design.

BROWNLEE, K. A. (Univ. of Chicago, Ill.). *Ind. Quality Control, 13,* 12–20 (1957).

An excellent review of exptl. design, covering the techniques and objectives, discussing the idea of randomization, and illustrating several of the more common types of design.

MISCELLANEOUS INFORMATION

The story of dehulled soybean oil meal.

HAFNER, F. H. (Soybean Div. General Mills, Minneapolis). *Soybean Digest, 17* (2), 14–15 (1956).

The latest development in the soybean industry is the introduction of toasted dehulled extd. soybean oil meal, commonly referred to as 50% protein dehulled soybean oil meal. The dehulled product contains none of the harsh fibrous coating that is present in the 44% protein product.

PATENTS

Method for making nut kernels friable.

BAILEY, D. R. U. S. 2,761,781, September 4, 1956.

A method of increasing the friability of nut kernels comprising fracturing the substance of the body of the kernels by confining the kernels and subjecting them while confined to pressurization and expansion of a gaseous fluid, the expansion of the gaseous fluid being over a substantial period of time as compared to an uncontrolled expansion thereof.

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(Continued on page 50)

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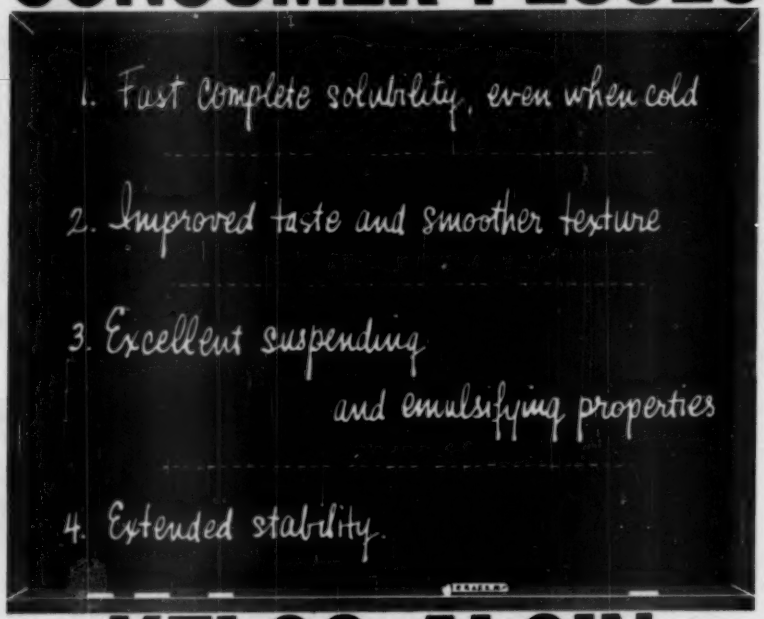
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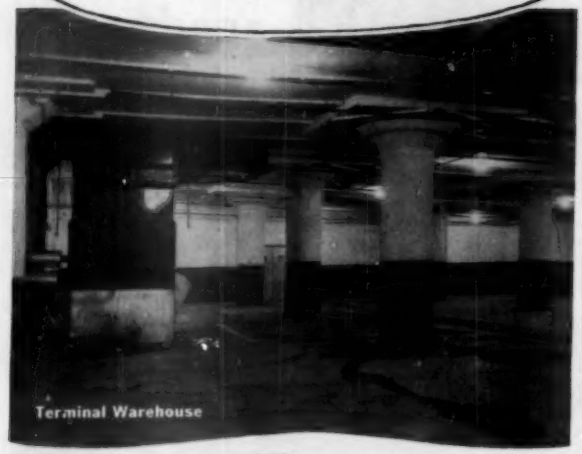

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In Memoriam

Herbert Charles Gore passed away at St. Petersburg, Florida, on April 2, 1957, at the age of 79.

Mr. Gore was born in New York City, June 19, 1877, the son of Willard and Anna (Guild) Gore. He attended the University of Michigan and received the B.S. Degree in 1899, and the M.S. degree at Ohio State University in 1901, where he worked in the laboratory of Dr. William Lloyd Evans.

He was employed as chemist at Ohio State University in 1901, teacher of science, Freeport, Illinois, 1901–1902, scientific assistant in the Department of Agriculture, 1902–1912, and chemist, Department of Fruit and Vegetable Utilization. He joined the Bureau of Chemistry, Department of Agriculture, Washington, D. C. in 1912, while Dr. Harvey Wiley was Chief of the Bureau. In 1924 he accepted a position at the Fleischmann Laboratories as research chemist. At this time he lived at 11 Windmill Lane, Scarsdale, New York. He retired in 1942 to St. Petersburg, Florida, where he spent the remaining years of his life.

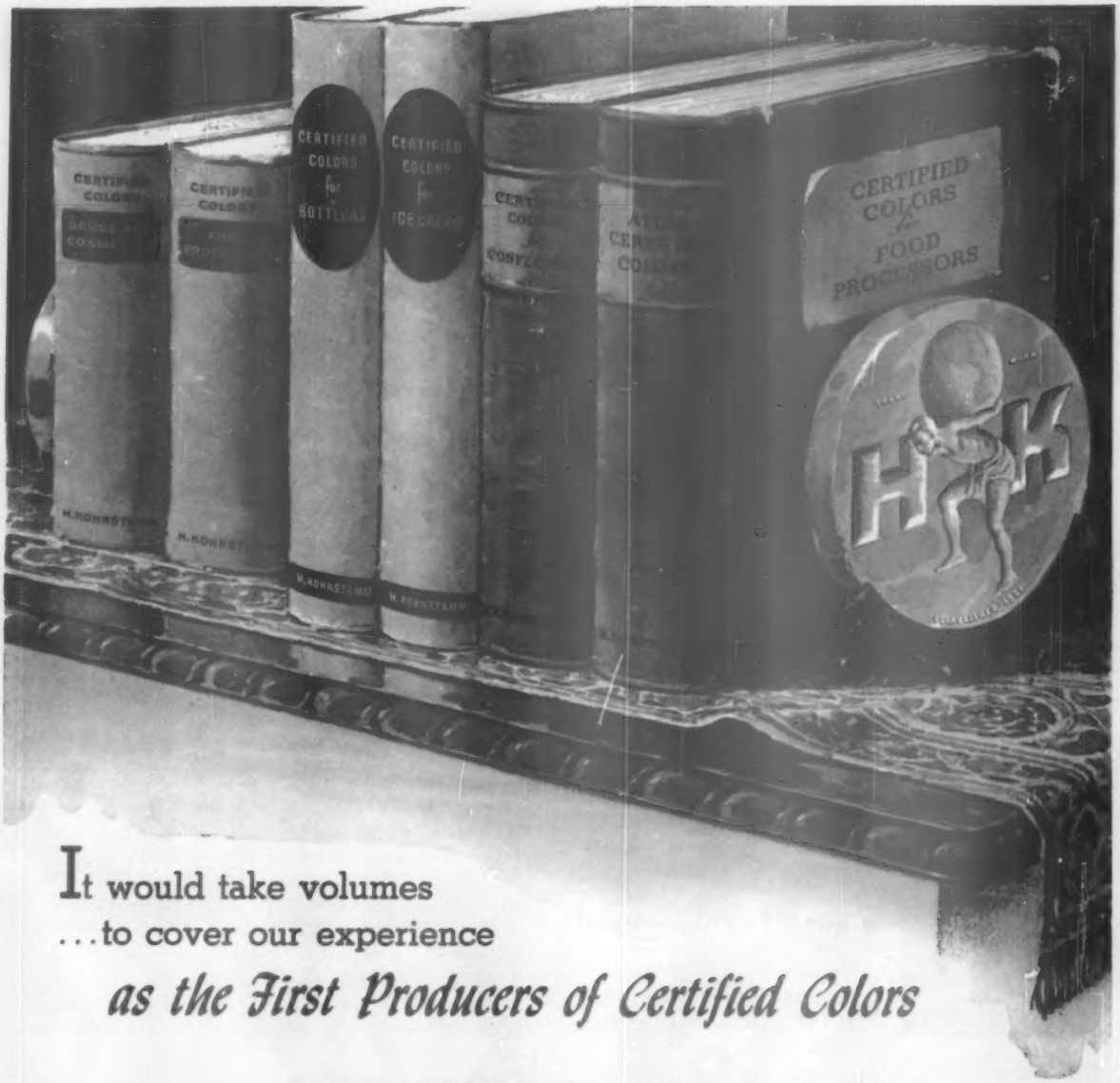
Mr. Gore made many significant contributions to enzyme technology, starch technology, and the chemistry of coffee and of soluble coffee. He was the inventor of the maltose sugar process, based on his discovery of a method of crystallizing maltose from a concentrated solution of maltose obtained by enzyme conversion of starch. His work on the preparation and utilization of malt syrups and dextrins, and the preparation with Dr. S. Jones of a stable canned malt syrup were of great economic importance. He was possibly the first scientist to prepare an orange juice by concentrating the juice to approximately 50 percent of volume, adding back a small amount of fresh juice, and freezing. He published numerous papers on the determination of sugar by the polarimetric method, technology of fruits and vegetables, cereal technology, and the measurement of diastatic activity. A number of important patents were issued to him.

He was a member of the American Chemical Society and the American Association of Cereal Chemists. His name was listed in *Who's Who* and in *American Men of Science*. Mr. Gore was a member of the Congregational church.

Mr. Gore was a cultivated, well-read gentleman. He was courteous and had a kindly personality, making firm friends wherever he worked. He enjoyed helping the young men and gave them encouragement and advice, and very often contributed to their work from his own experiments. He enjoyed his friends and took an active interest in the social life of his community. He was a staunch American and a firm believer in the evolutionary processes as a means of social progress.

In 1903 he married Pamela Taylor. Her charm, understanding and consideration for others made their home a happy one where their numerous friends were always welcome. Besides his wife he is survived by two sons and two daughters: Richard Taylor Gore, Professor of Music at Wooster College, Wooster, Ohio; William Robert Gore of New York City; Harriet Williard Looney of Washington, D. C., and Winifred Loewen of Decatur, Illinois, and 7 grandchildren.

Contributed by *Charles N. Frey*



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(Continued from page 40)

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An exclusive vacuum dehydrator was featured by Chain Belt Co. at IFT's 17th annual meeting held recently in Pittsburgh. G. K. Viall, vice president of research and development, and Weld Conley, manager of the Chain Belt research and development division, both IFT members, and sales engineers Fred Fixari and Jerry Bard were on hand to describe the new machines.

The company currently is offering bulletins No. 55-126 and 55-127 on vacuum dehydrators. Copies can be obtained by writing Chain Belt Co., Milwaukee 1.

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Aluminum Co. of America has introduced a cast aluminum stair tread that is said to combine safer footing with long-term maintenance savings. Designed for use where stairs are subject to extreme weathering or corrosive atmospheres, the aluminum tread utilizes a slip-proof abrasive strip at the outer edge. A special aluminum alloy is said to insure high corrosion resistance and strength, and long, maintenance-free life. Because the grating is cast in one piece, concentrated loads are distributed more evenly over all bearing bars. Although designed to carry the weight of a man, the stair has withstood loads in excess of 3,000 lb., according to the manufacturer. The new stair is available in three finishes: "structural," for ordinary industrial applications; "marine," for shipboard use; and "polished," for sanitary stairways in food processing plants. Specifications can be obtained from the manufacturer at 1501 Alcoa Bldg., Pittsburgh 19.

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Robert A. Main & Sons, Inc., recently introduced a new pin-type conveyor chain that is made entirely of stainless steel and is especially recommended for food industry applications. The new chain, forged and heat treated, can be furnished for acid or special heat conditions, and its simple design makes it easy to take apart or assemble. Each link has an integrally cast wing attachment to which wood or metal conveyor slats can be attached for all types of duty. The chain can be used in single or multiple strands and, because of its uniform size, the links need not be matched. It is available in standard pitches.

Full information is available from Robert A. Main & Sons, Inc., 257 Pascack Rd., Paramus, N. J.

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Adolph's Liquid Meat Tenderizer, available in the retail market for some years, now is available in unlimited quantities to the meat processing industry. According to a company announcement, the new product was developed especially for use on meats that are to be frozen. Technical information can be obtained from Adolph's Industrial Food Products Co., Box 8616, Los Angeles 46.

◆ ◆ ◆

Michigan producers have high hopes for a new canned product, red cherry sauce, recently introduced after more than a year of experiment and testing by American Can Co. and the packers. Developed to promote the sale of Michigan red tart cherries, the sauce is said to be ideal for use with ham and other meats, fish and fowl. The "Michigan Queen" brand of Traverse City Canning Co. and the John C. Morgan Co. "Morgan" brand now are being distributed in chain and other retail stores in Michigan, and a promotional campaign currently under way is aimed at developing a national market.

◆ ◆ ◆

Plant engineers are being introduced to a new type of vinyl plastic wall covering that is said to have easy maintenance characteristics desirable in food and beverage processing plants.

Developed by Armstrong Cork Co., the new wall tile is fire-resistant and is said also to have a high degree of resistance to staining, fading, scuffing and the effects of moisture. The new vinyl tile is unharmed by soaps, detergents, alkalis and moisture, and scratches may be removed by cleaning and rubbing with wax or a cleaning agent, according to the manufacturer. Made of vinyl plastic and asbestos fibers, the tile is said to be easy to install and can be formed to sharp angles by heating with a blow torch. Currently made in the 9 by 9 size, it is available in a softly textured design in nine colors. Other colors and sizes may be added in the future.

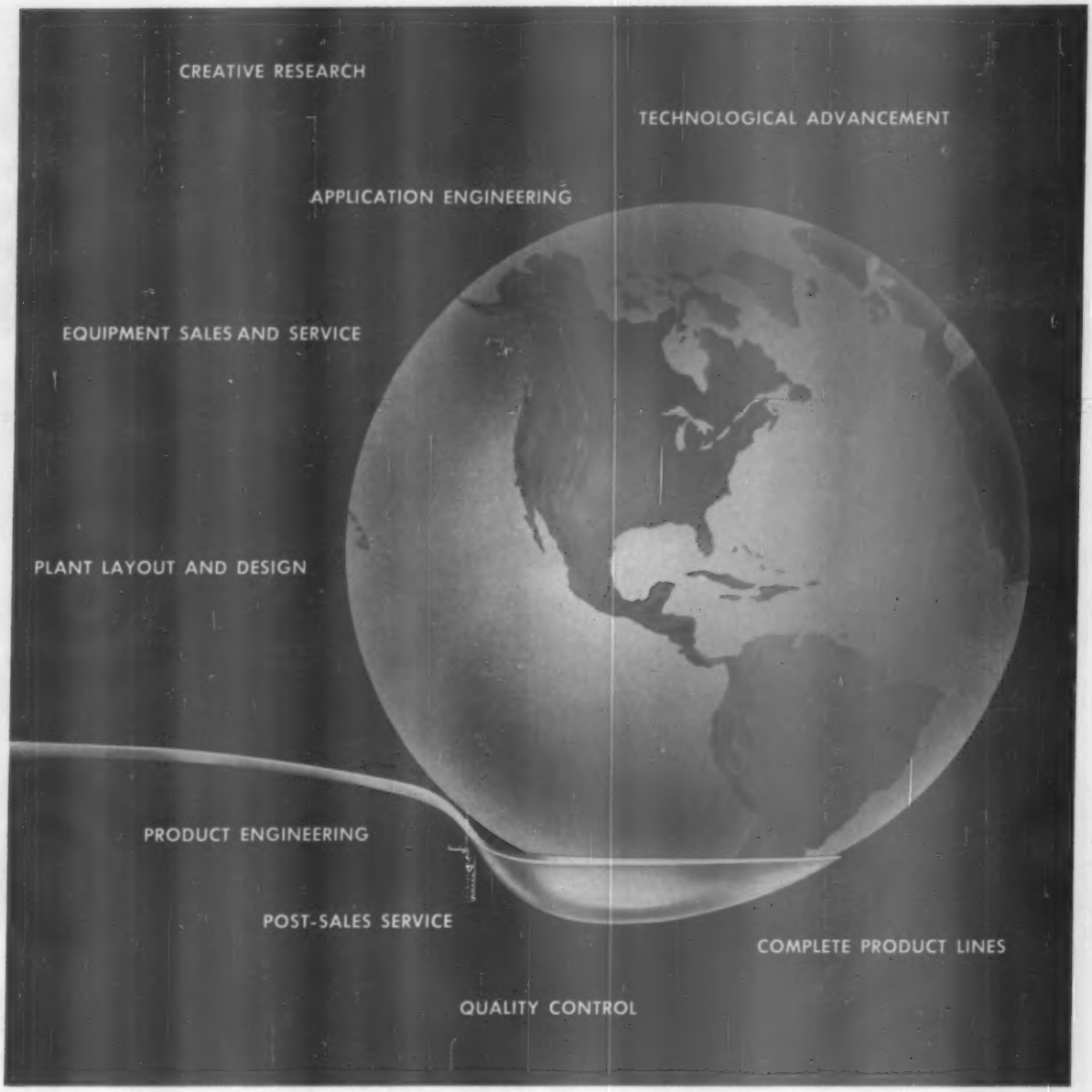
Full information about the tile can be obtained from Armstrong Cork Co., Lancaster, Pa.

◆ ◆ ◆

Oakite Drycid, a new powdered acid material said to remove rust, scale and corrosion with greater safety to metal surfaces, was introduced recently by Oakite Products, Inc. Added to water in concentrations of up to 8 oz. per gal., Oakite Drycid is said to go into solution swiftly and to be useful when applied by circulation or immersion. Solutions of the compound can be used cold or, for faster action, heated to 165° F. It is said to be effective in removing scale, scale-like deposits, rust, iron sulphides and other oxides.

Advantages claimed for the new product include its mild, aromatic odor and non-fuming characteris-

(Continued on page 58)



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FMC is the world's largest manufacturer of food preparation and processing equipment. Its extensive operations reach to the faraway corners of the earth. Affiliates and subsidiary companies in England, South Africa, Australia, Belgium, France, and other foreign market centers, have broadened the scope of the Canning Machinery Division far beyond United States borders. Yet through its more than 70 years of worldwide growth, FMC has worked on the theory that all business, wherever it is, is local—and that all service must be specially tailored to the individual need. Let us show you how we put this theory into practice. A card or a call will be promptly acted on here at FMC.

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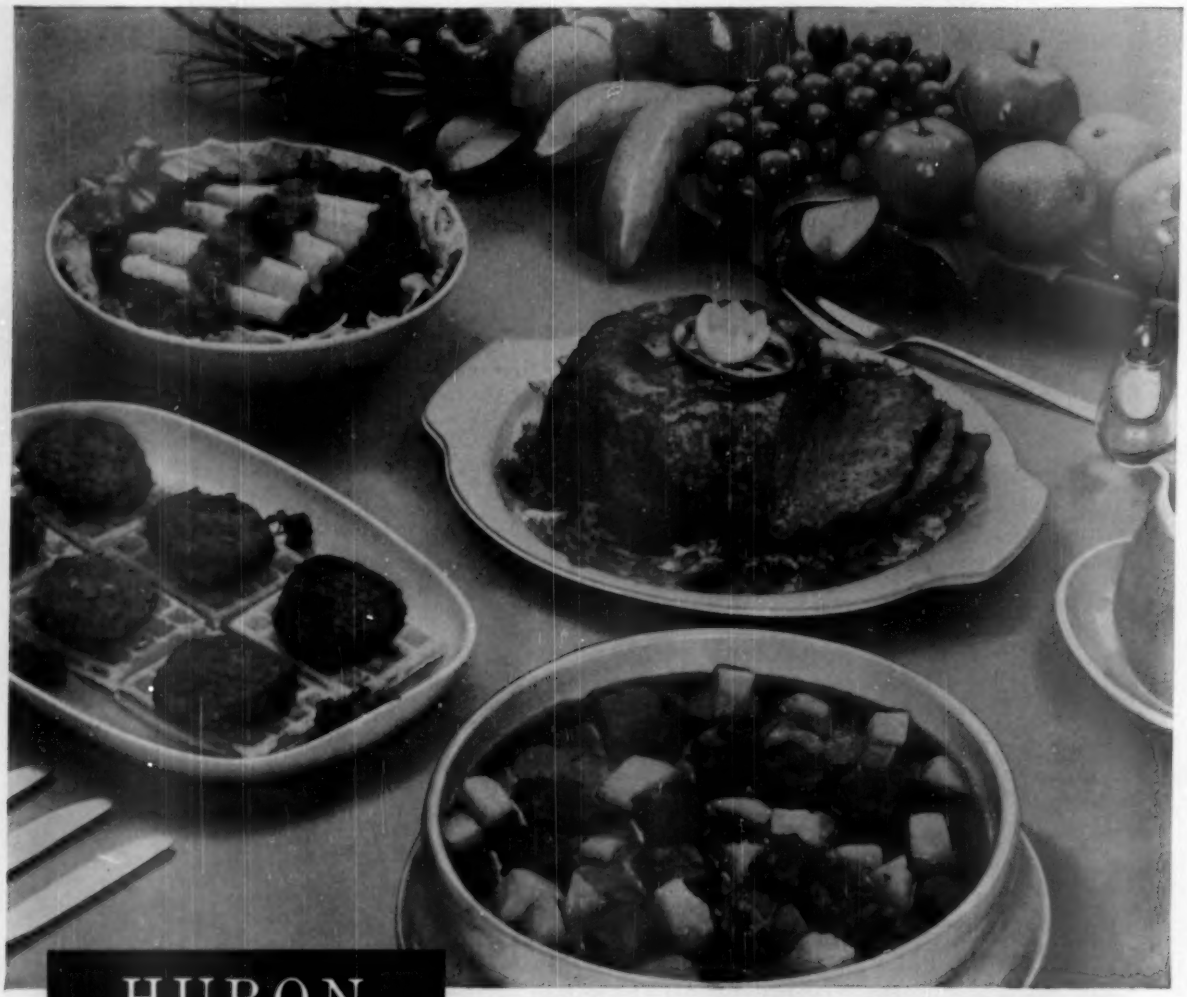
Canning Machinery Division
General Sales Offices:
WESTERN: SAN JOSE, CALIF. • EASTERN: HOOPESTON, ILL.



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Poultry Pies
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More and more food processors and packers are using Huron HVP—the Hydrolyzed Vegetable Protein that gives their products the rich "come-and-get-it" flavor of well-browned beef . . . a delicious meaty taste that fortifies the flavor of many foods. It is particularly effective with those foods that contain long-simmered ingredients—soups, gravies, stews, etc.

The flavor of seafoods and fish products is improved remarkably through the addition of HVP. Just a touch added to seafoods gives them a delicate background flavor without dominating the over-all effect—in fact, the addition of HVP actually complements the principal flavor! Huron is America's largest manufacturer of HVP and the only company offering you this complete line of liquids, pastes and powders, each one tailored to fit a specific need. Fill in the coupon below for complete information and testing samples.

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INCORPORATED
Wilmington 99, Delaware

Sales Offices: 380 Madison Avenue, New York 17, New York; 332 South Michigan Avenue, Chicago 4, Illinois; 120 Montgomery Street, San Francisco 4, California.

(Continued from page 54)

ties, and its greater safety on aluminum, brass and galvanized surfaces, when used as recommended. Further information on Oakite Dryeid is available from Oakite Products, Inc., 19 Rector St., New York 6.

◆ ◆ ◆

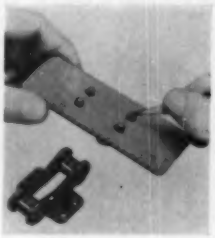
Barnett Laboratories, Inc., Long Beach 5, Calif., announced recently a new product, oleoresin paprika, said to conform in all respects to the requirements of the National Formulary. Because it is extracted from California-grown pods, the new product offers users the advantages of an uninterrupted source of supply, according to the manufacturer. Oleoresin paprika initially is being standardized at 30,000 and 40,000 color units.

◆ ◆ ◆

The first surface-active agent to be made from sugar has been produced at the pilot plant of Berkeley Chemical Corp. Marketed as Sucrodet D-600, it is a recrystallized sucrose dipalmitate, developed primarily for use in the food, pharmaceutical and cosmetics industries, and for use in basic application research. The manufacturer plans to follow Sucrodet D-600 with sucrose esters derived from stearic, oleic, myristic and lauric acids. A technical data sheet on Sucrodet D-600 is being prepared, and development quantities can be ordered from the exclusive sales agent, Millmaster Chemical Corp., 295 Madison Ave., New York 17.

◆ ◆ ◆

A flat-top conveyor chain that combines a smooth, rivet-free nylon carrying surface with precision steel roller chain now is available from Link-Belt Co. The new chain is described in a folder, No. 2492, which illustrates its use in conveying cans, bottles, packages, small parts and similar items.

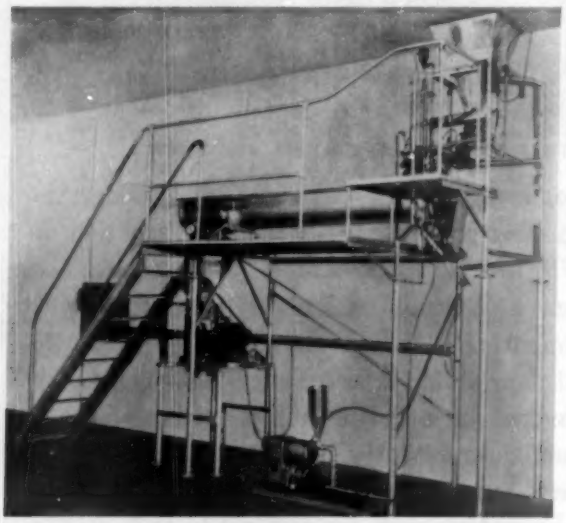


Called Ny-Steel flat-top roller chain, it can be furnished with nylon top plates assembled on either heat-treated carbon steel chain or on stainless steel chain. According to the manufacturer, Ny-Steel chain is long lasting, shock absorbent and resistant to chemicals and corrosion, and does not stretch; its weight is less than half that of similar all-steel chains.

Dimensions and specifications in folder No. 2492 can be obtained from Link-Belt Co., Prudential Plaza, Chicago 1, Ill.

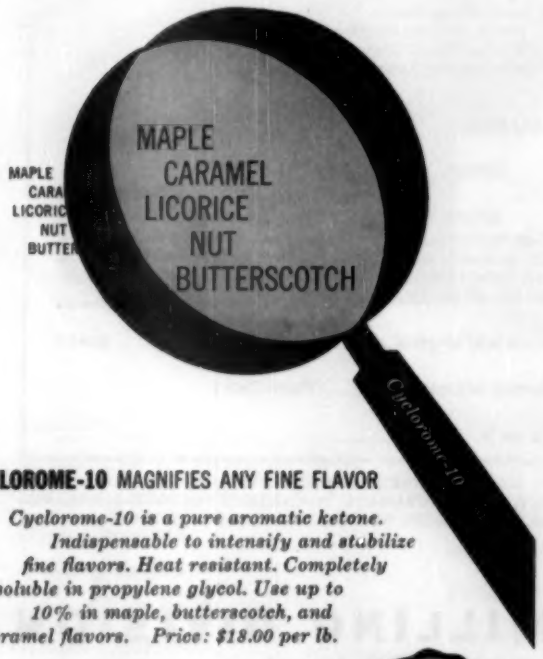
◆ ◆ ◆

A processing machine designed to make powdered foods more easily wettable has been introduced by the Dairy Equipment Dept. of the Blaw-Knox Co., Mora, Minn. Called the Solubilizer, the new unit is a companion to the company's recently introduced Instantizer, which converts dry skim milk powder to "instant" dried milk through an agglomerating process.



Material to be processed by the machine feeds by gravity from a bin through an enclosed bank of spray nozzles which atomize the solubilizing agent. The material then is carried by screw conveyor to intermediate packaging equipment. According to Blaw-Knox, important operating features of the Solubilizer include its adaptability for wet and dry blending of

(Continued on page 61)



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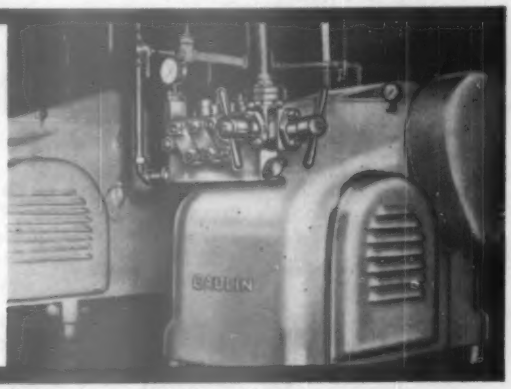

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BOOKS . . .

SCIENCE AND ECONOMIC DEVELOPMENT. Richard L. Meier. John Wiley and Sons, Inc., New York and the Technology Press, M.I.T., Cambridge, Mass. 266 pages, 1956.

This book deals with problems vital to all of us today and perhaps even more important to our children and grandchildren. Briefly, the question is: What form should or will the development of human society take with technological development, ever-increasing population pressure, increasing scarcity of resources, and a rapidly developing universal demand for the minimum necessities and comforts of life?

The author does not set out the pattern for an Utopia. He first catalogues the resources of capital, soil, food, energy, minerals, etc. and then defines minimum human requirements. These parts of the book are fascinating. The presentation of the vast amount of data is simple and clear. As expected, this assessment once again pinpoints the great discrepanies in the standard of living of people in various parts of the world. Finally, on the basis of resources and needs, the author assigns priorities to the various phases of development and then attempts to visualize the probable development of society. Here a good balance is attained between the inevitable (and often unpalatable) conclusions from the stock-taking of resources and needs and, shall we say, the aspirations of a technocratic society.

Readers of FOOD TECHNOLOGY will be most interested in the discussions pertaining to food. Dr. Meier goes into considerable detail on the psychological background of food preferences and the conditions under which new foods can be introduced and may be accepted. These parts of the book will interest every executive who is worrying about the processed foods of the future. More than that, this reviewer believes that both those interested in the food industries and in the over-all feeding problems of the human race will welcome this brief evaluation of resources, possibilities, and limitations.

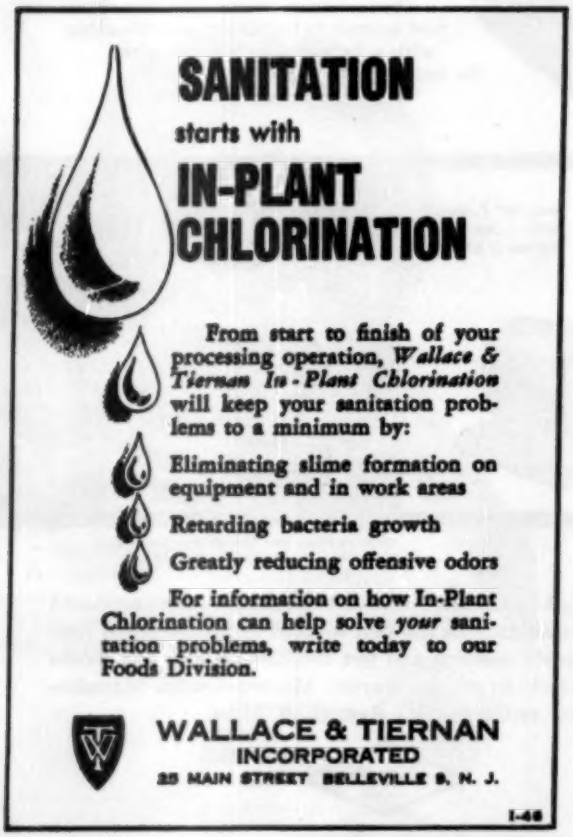
Some will disagree with some of Dr. Meier's projections, and of course this is inevitable. This reviewer, for instance, questions the rationale of the envisoned small fruit and vegetable producing belts around the housing units of the megapolis. This would be indeed a wasteful manner in which to supply needs, particularly in climates with long winters. There are other points where food technologists will differ with Dr. Meier. However, his projections are based on cold facts relating to resources and average human needs, and, let us face it, rationality is not always a strong feature of economic development as we know it today.

The background literature quoted by the author is impressive; the illustrative material is ample, clear, and often ingenious. How refreshing that at last scientifically trained minds are turning to such tasks as setting the over-all pattern for supplying human needs. This challenging book ought to invigorate our thinking with regard to the future, and thus help us in meeting the myriad problems pertinent to the role of science and technology in future economic development.

Z. I. KERTESZ
Geneva, New York

ADVANCES IN PROTEIN CHEMISTRY. Edited by M. L. Anson, K. Bailey and J. T. Edsal. Vol XI, x + 665 p. Academic Press, Inc., New York, 1956.

The current rapid expansion of knowledge and technique in biological and physical sciences which has made mastery of a single discipline so difficult is particularly true of biochemistry. The chemistry of naturally occurring constituents and the metabolic changes that occur in these has expanded so rapidly in recent years that specialization has become inevitable. It is fortunate that, in the recognition of this trend, the available literature in specialized fields has been collated and critically reviewed by selected recognized experts in the series of annual publications such as *Advances in Protein Chemistry*. Recognition of the rapidly expanding literature in biochemistry, and the inadequacy of available texts and reference works, led in 1931 to the establishment of Annual Reviews, and the publication in 1932 of Volume I of *Annual Reviews of Biochemistry*. Monographs, handbooks and several types of annual reviews in biochemistry were available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from European and particularly German publishing firms. As a result of conditions leading to World War II, the old and well established Academische Verlagsbuchhandlung transferred their activities to the United States and founded the Advances series here. Of these the *Advances in Protein Chemistry,* introduced in 1944, was one of the earliest, being preceded only by *Advances in Enzymology* and *Vitamins and Hormones.*

From its inception in 1943, the editors of *Advances in Protein Chemistry,* have established and maintained high editorial standards in selection of timely fields and of recognized experts to prepare the reviews; the technical standards of publication, format, freedom from typographical errors, adequacy of appendices, etc., also have been high. These high standards characterizing the previous ten volumes have been maintained in this, the eleventh volume.

As is the previously published volumes, the topics discussed include major landmarks in the development of the field both in basic chemistry of proteins and in methodology. The present volume is particularly valuable historically because articles in the same or similar field had been published in earlier volumes and so afford an opportunity to assess the significant advances made in the field of protein chemistry since this series was begun. The six articles presented include discussions of protein structure in relation to function and biosynthesis; the chemistry of two of the hormones of the anterior pituitary gland; complex formation between metallic cations and proteins, peptides and amino acids; two articles on methodology that have enabled the recent advances in our knowledge of protein chemistry—column chromatography and countercurrent distribution; and an article on the new technique in protein chemistry investigations—diffusion coefficients.

That the references cited have been critically reviewed and discussed is quite evident from analysis of frequency of citation. The six articles, varying in length from 46 p. to 126 p., average 92 pages in length; the references cited vary in number from 106 to 325 per article, and average 233 per article or about 300 per 100 pages of text (as compared with over 500 per 100 pages of text in the *Annual Review of Biochemistry* or 450 for *Chemical Reviews*). It is actually in the citation of references that the greatest difference in style occurs; in three of the articles the references are numbered and cited by author and number and in the others they are not numbered and cited by author and year.

Of the six articles, that on complex formation and the two on column chromatography and countercurrent distribution will be of greatest interest to food technology. The catalytic properties of metal-proteins complexes is well known and the fundamental chemistry of such complex formation is well summarized. Methodology in the protein field is widely applied in other related fields and the critical, thorough presentation of the basic principles given can be most useful.

M. A. Joslyn
Berkeley, California

FOOD INDUSTRY TOPICS

(Continued from page 58)

wetting agents, liquid flavoring and vitamin additives with a dry powder.

Coupled with the Instantizer, the Solubilizer can prepare a wide variety of "instant" mixes. For example, a processor could produce wettable cocoa with the Solubilizer alone, or an instantly wettable powdered chocolate milk drink with both the Instantizer and Solubilizer.

◆ ◆ ◆

The baking industry is offered an improved mold and rope inhibitor, packaged in a new moisture-resistant container. Introduced by Du Pont's Polychemicals Dept., the improved Mycoban sodium or calcium propionate is said to feature better uniformity, finer texture, increased density, a lower moisture content and freedom from foreign odor. To give better protection against moisture and other forms of contamination, the 250-lb. drums in which the improved Mycoban is packaged are lined with heavy-gauge polyethylene film. Drums containing the improved product are identified with a distinctive label featuring the word "improved." The product is being handled through Du Pont's regular marketing channels.

. . . *things new under the sun*

Aluminum Company of America, at the recent National Packaging Exposition in Chicago, displayed a series of futuristic packages foreshadowing new developments in food marketing. Included were prepared cake frosting in a pastry-gun package; a cheese carton, one side of which is a rigid-foil grater; a prepared and frozen cheese rarebit packaged in its own rigid-foil double boiler; macaroni-and-cheese with the macaroni packaged in a perforated foil bag in which it can be cooked and drained; and a cake mix package containing two foil baking pans so that the cake can

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

July 22–24	Seventy-fifth Annual Convention of the National Macaroni Manufacturers Association, Grand Hotel, Mackinac Island, Michigan
August 19–23	Gordon Research Conference on Food and Nutrition, Colby College, New London, New Hampshire
September 8–13	One hundred thirty-second National Meeting of the American Chemical Society, New York, N. Y.
September 30–October 2	Fall Meeting of the American Oil Chemists' Society, Netherland-Hilton Hotel, Cincinnati, Ohio
October 9–11	Fourth Annual Symposium on High Vacuum Technology, Hotel Somerset, Boston, Mass.
October 14–16	Association of Official Agricultural Chemists, Shoreham Hotel, Washington, D. C.
November 18–December 9	Ninth Pacific Science Congress of the Pacific Science Association, Chulalongkorn University, Bangkok, Thailand

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

be cooked one half at a time. All of these ideas recently were presented by Alcoa as suggestions for Kraft Foods Co. None is scheduled for actual production.

Also in the Alcoa display were two new packages recently introduced in test markets. One is a flour shaker container being tested by Pillsbury Mills, Inc., while the other, being tested by Armour & Co., is a rigid-foil tray designed for storing, cooking and serving chicken.

◆ ◆ ◆

A low-cost, self-operating ion exchange water demineralizer has been introduced for laboratories that require moderate quantities of mineral-free water. Called the Crystalab Deeminac SD-326, the unit operates unattended and produces 2-3 quarts per hour in normal service; for hurried requirements, the polyethylene bottle can be squeezed to accelerate the flow. The complete unit consists of a quart-size demineralizing unit with filter, a metal holding stand, and a quart-size graduate fitted with a tight cover. Crystalab Deeminite ion exchange resins in the filter turn from blue to brown as their power is exhausted; when they are entirely brown, a new filter unit can be plugged in instantly.

Full information and prices for the unit can be obtained from Crystal Research Laboratories, Inc., 29 Allyn St., Hartford 9, Conn.

◆ ◆ ◆

Du Pont has announced a new type of Mylar polyester film that can be heat-shrunk to provide a clear, durable, skin-tight wrapping for smoked meats and poultry. With the exception of its heat-shrinkable characteristic, the new film is said to retain the essential properties of standard Mylar: durability under temperature conditions from —80° to 300° F.; highest tensile strength of any transparent film; excellent tear resistance; and resistance to oils and greases.

The shrinkable Mylar is available in cut-to-size or continuous-tubing forms, either plain or printed. Closure equipment is commercially available, and existing equipment can be used with minor modifications. For further information, contact Jack Burchenal, 9448 Nemours Bldg., Wilmington 98, Del.

◆ ◆ ◆

S. B. Penick & Co. now is producing Heliogen, a diatomic iodine sanitizer, in a new effervescent tablet form packaged in individually sealed, moisture-proof aluminum foil. The new product makes it possible to prepare sanitizing solutions simply by dropping a tablet into water.

Effective in hard or soft water, the tablet releases diatomic iodine which destroys bacteria, viruses and fungi within 15 seconds, according to the manufacturer. Each tablet releases the exact amount of diatomic iodine required for 2½ gal. of solution, and the solution is said to be non-toxic, non-corrosive, and non-irritating to the skin.

Further information about Heliogen tablets can be obtained from S. B. Penick & Co., Sanitizing Products Div., 50 Church St., New York 8.

◆ ◆ ◆

The Dave Fischbein Co. has produced a table-model carriage conveyor for use with its Fischbein portable bag closer. Designed for economical closing of smaller bag sizes, the unit is designed so that the operator places the bag on the free-rolling carriage and guides it through the sewing operation, and the carriage then returns automatically to the starting position. The bag closer is locked onto the conveyor unit by turning a single knob, and can be removed instantly for use elsewhere. Details are available from the maunfacturer at 2720 30th Ave., So., Minneapolis, Minn.

◆ ◆ ◆

Powers Regulator Co. has introduced a new wet-bulb thermal system that is said to be highly resistant to the corrosive effects of smoke or gases as well as to electrolytic action of wet-bulb water. Wet-bulb jackets are of Heliarc-welded 316 stainless steel, heat-treated, normalized and polished to eliminate the pits in which corrosion often starts. The mounting panel for the instrument has all metal parts carefully insulated to prevent any galvanic action between the wet bulb and other exposed metal.

Further information and suggested applications can be obtained by writing Powers Regulator Co., 3434 Oakton St., Skokie, Ill.

. . . *the literary corner*

Ten new packaging ideas for frozen seafood are spotlighted in a brochure just released by Ekco-Alcoa Containers, Inc. The company says the new ideas will offer the seafood processor brilliant new packages with the added advantage of consumer convenience. For example, fish fillets and sauce are shown in a convenient heat-and-serve container, and other items featured include gleaming new packages for breaded precooked shrimp and sauce, fish sticks, salmon patties and complete fish dinners. Copies of the brochure can be obtained from Ekco-Alcoa Containers, Inc., Wheeling, Ill.

◆ ◆ ◆

Posters featuring the rules for proper storage and handling of cellophane now are available. Designed to be hung in the storage and wrapping areas of packaging plants, the two 17 by 22 posters are colorfully designed with large type, simple language and frequent illustrations to make the rules easy to read and understand. Copies of the posters can be obtained from the Market Development Dept., American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3.

◆ ◆ ◆

The Valve Div. of Minneapolis-Honeywell Regulator Co. has published two new specification sheets

giving construction details for single- and double-seated Honeywell Series 800 diaphragm control valves. Included are sizes, materials, plug characteristic curves, dimensions and a cross-section of each type. Request Specifications S810-11 and S810-12 from the Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 23.

◆ ◆ ◆

A comprehensive catalog describing its newly acquired Eppenbach line of wet mixing and homogenizing equipment is being offered by the Gifford-Wood Co., 420 Lexington Ave., New York 17. Three types of Eppenbach mixers and homogenizers are covered in the 24-page catalog. The text discussion includes operation, specifications, dimensions, applications and possible modifications for various models of these three units.

◆ ◆ ◆

Any community group planning a rodent control program is offered copies of a new booklet featuring specific instructions on how to run a community campaign. Published by the Wisconsin Alumni Research Foundation (WARF), the booklet is said to represent the most readable and authoritative source of information on rodent control.

WARF officials, in announcing the booklet, pointed out that rats cause a billion dollars worth of damage each year to U. S. food, property, human beings and livestock—a figure equalling the production of more than 100,000 average American farms.

Copies of the booklet are being distributed to agricultural leaders through state extension specialists and 4-H and FFA administrators. Additional copies, for community programs, can be obtained from the Educational Dept., Wisconsin Alumni Research Foundation, Box 2217, Madison, Wis.

◆ ◆ ◆

A complete line of corrosion-resistant fittings for use on stainless steel piping installations is illustrated and a booklet issued by Horace T. Potts Co., Erie Ave. & D St., Philadelphia 34. Included are tabular specifications for all fittings necessary for standard plant installations. A double-page diagram illustrates the special features of Speedline fittings.

◆ ◆ ◆

Eight pages of useful information about Irish moss (carrageen) and its extractives (carrageenan) make up the special technical issue of "SeaKem Extracts," the house organ of Seaplant Chemical Corp., 63 David St., New Bedford, Mass. Other items in the special issue include a full-page table listing the characteristics of 27 SeaKem stabilizers, and a feature article, "How to Use SeaKem Stabilizers."

◆ ◆ ◆

Paisley Products, Inc., is offering a new reference data file on its sprayable, non-slip treatment for corrugated containers, Non-Slip Container Coating No. 1715. The file contains a 1957 revision of the Paisley laboratory report on the product, as well as an analysis of the techniques used and benefits enjoyed by a major oil company. The file also offers an inventory of equipment suitable for applying the coating with existing production, packaging or conveyor lines. Cop-

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ies of the data file can be obtained by writing on company letterhead to Paisley Products, Inc., 630 W. 51st St., New York.

Carl H. Haurand

. . . *the human element*

Carl H. Haurand has been elected vice-president in charge of manufacturing for the Best Foods, Inc., New York City. Mr. Haurand, who has been with the company since 1927, formerly was manager of plants. His election followed the retirement of Harold B. Viedt, who had been a director and vice-president.

Pierre T. Deleamont has joined Firmenich & Co., New York City, as a sales representative. A graduate of the University of Geneva, Switz., he has been active in the perfume industry in Switzerland and the U. S. for the past 11 years.

Alexander N. McFarlane, vice-president and general sales manager of Corn Products Refining Co., has been elected president of Corn Products Sales Co. Mr. McFarlane has been with Corn Products since 1934, when he joined the technical service department. He had been vice-president of the sales company since 1953.

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Frank J. Drago is the newly appointed sales manager of Sheffield Chemical, a subsidiary of National Dairy Products Corp. Mr. Drago, formerly with National Cash Register Co. and Procter & Gamble Co., will make his headquarters at Sheffield's Norwich, N. Y., office.

Robert B. Ball

Robert B. Ball has been named director and vice-president in charge of manufacturing and engineering for Diamond Crystal Salt Co., St. Clair, Mich. In other company appointments, **Edward M. Dodd** of Louisville, Ky., was made assistant to the president; **Russell D. Rudolph** of Jefferson Island, La., was named a vice-president; and **Charles D. Croneworth** of St. Clair was appointed manager of the St. Clair plant, the position formerly held by Mr. Ball.

R. O. Keiser has retired from active service after 45 years with Proctor & Schwartz, Inc., Philadelphia. For the last 34 years he had been in charge of sales to the process industries, and he was the founder of the company's experimental department, after joining the firm in 1912. Succeeding Mr. Keiser as process industries sales manager is **A. G. Blank,** who has been with the company since 1929.

R. O. Keiser

Robert W. Polley has been named vice-president in charge of manufacturing for Nashua Corp., Nashua, N. H. An engineer and veteran executive, Mr. Polley rose through the ranks to become one of the firm's youngest vice-presidents at the age of 40. He had been manager of manufacturing since 1955.

William N. Henderson has been named by van Ameringen-Haebler, Inc., New York City, to coördinate research and development efforts throughout the company. Mr. Henderson formerly was with Allied Chemical & Dye Corp. for many years.

Bruce Alexander has been appointed manager of technical services at the Washington, D.C., office of Blaw-Knox Co. He succeeds **Marvin Marcus,** who had represented the company since 1945 and who resigned to establish his own business as a consulting engineer.

R. G. Moench & Co., Clark, N. J., has announced appointment of two representatives: R. D. McLellan Co. of Richmond Hill, N.Y., to cover the New York City area, and G. Gray Simpson & Son of Norfolk to cover Virginia and North and South Carolina.

Joseph I. Brennan has been appointed to the staff of van Ameringen-Haebler, Inc., New York City. He

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Institute of Food Technologists

THE PROFESSIONAL SOCIETY OF FOOD TECHNOLOGISTS

The Institute of Food Technologists numbers among its active members leading scientists, technologists and engineers in the field of Food Technology.

The Institute invites your professional association with this select group of scientific and technological workers. Only those who are qualified by education, special training, or experience are extended this invitation.

Food Technology may be defined as the application of science and engineering to the production, processing, packaging, distribution, preparation and utilization of foods. Scientists, technologists and engineers engaged in Food Technology, executives, officials and supervisors under whose jurisdiction Food Technology operations are conducted, research investigators, teachers, and others working in the field of Food Technology, will find membership in the Institute worth many times its modest cost.

If you can meet the qualifications for membership, you owe it to yourself and to your business or profession to become a member.

OBJECTIVES

The Institute is a non-profit, professional, educational association to promote the application of science and engineering to the production, processing, packaging, distribution, preparation, and utilization of foods; it stimulates investigations into technological problems arising therein, it provides a medium for presenting and discussing the results of such investigations; it stimulates and provides means for the free interchange of technological information and ideas among food technologists; it promotes recognition of the role of food technologists in the technical direction of operations in these fields; all of these activities have the ultimate objective of providing better and adequate foods for mankind.

ORGANIZATION AND PROGRESS

Organized July 1, 1939, at Cambridge, Mass., with a membership of less than 100, the Institute has grown to more than 4,900 (1956). It is world-wide in scope, with members in North, Central, and South Americas, the Scandinavian countries, England, Holland, Germany, France, India, Australia, and New Zealand.

MEMBERSHIPS

Professional Members. Any person who is ethically qualified, and who has had training and experience in food technology, or any person who in the opinion of the Council is recognized as distinguished in the contributing sciences as they apply to foods, shall be eligible to be a Professional Member of the Institute. The minimum training which shall qualify a candidate for eligibility for Professional Member is, in general, graduation from a college, university, or similar institution in which he has majored in one or more of the sciences or branches of engineering associated with food technology. The minimum experience shall be three years experience in food technology. The Council may, at its discretion, waive any or all of the foregoing requirements in the case of a person who, thru long experience has distinguished himself in the field of food technology.

Members Any ethically qualified person, active in special or limited aspects of food technology, who is an administrator, director or executive under whose jurisdiction operations in food technology are conducted; or who is engaged in the dissemination of knowledge of food technology; or one whose work requires a general knowledge of the broad principles of food technology as it applies to the products, processes or equipment with which he or she is concerned; or one scientifically trained in and who has entered a career in food technology; shall be eligible to become a Member.

Student Members. Any ethically qualified person who has never been a Professional Member or Member of the Institute, who is registered as a student in an educational institution with at least Junior (third year) standing, who is a candidate for a Bachelor's or higher degree in one or more of the sciences or branches of engineering associated with food technology, shall be eligible for membership as a Student Member. This classification shall be his status only until the end of the calendar year in which he completes his schooling. When graduated and otherwise qualified as defined in the section on "Members," a Student Member may, upon application, be elected to Membership.

DUES

Professional Members and Members—$7.50 per year; Students—$2.50 per year. Dues include a subscription to Food Technology.

PUBLICATIONS

Food Technology, issued monthly, is the official journal of the Institute. It is published to advance the profession of food technology by disseminating the results of research and their practical application in industry. Contributors to its pages represent many fields of scientific and technological interest.

Food Research, published bi-monthly, is devoted to publication of the results of original investigations and occasional reviews in the fields of food and beverage technology, chemistry, and microbiology. Food Research is available to Institute members at the special rate of $7.50 per year.

REGIONAL SECTIONS

Where sufficient members (25 or more) live within commuting distance of a given point, a Regional Section may be established. Such Sections are able to hold meetings at more frequent intervals than the National group, thus affording the food technologists regular opportunities for an xechange of views and ideas with others in the area. There are presently 28 Regional Sections.

ANNUAL MEETINGS

Each year one of the regonal sections acts as host to the Institute at an annual meeting. The program of this annual conference is designed to acquaint members with various phases of food production, processing and distribution, and to keep them abreast of current trends and technological developments. The speakers invited are those whose subjects will build a well-rounded program, of interest to the greatest number. Annual conferences are highlighted by exhibits of new equipment, processes and special ingredients.

AWARDS

The society administers the following awards:

NICHOLAS APPERT AWARD (Medal). Each year the Chicago Section of the Institute makes this award to a person whose contributions to the food industry make him distinguished and outstanding in the opinion of the national jury.

BABCOCK-HART AWARD ($1,000.00). The purpose of this award, made by the Nutrition Foundation, is to encourage contributions to Food Technology which will have an influence on the nutritional well-being of the general population.

FLORASYNTH FELLOWSHIP AWARD. $1,000 granted annually to a young man or woman under 35 years of age, engaged in senior undergraduate or graduate work, as a candidate for an advanced degree, in recognized educational institutions in the United States or Canada, which is conducting fundamental investigations for the advancement of Food Technology.

GENERAL FOODS FELLOWSHIP AWARDS. Three Fellowships will be granted annually—no more than two to the same educational institution for the same calnedar year, but will be renewable upon application to and approval by the Awards Committee of the Institute for a maximum of three years, in order to provide for continuity of studies leading to a doctorate degree. if the candidate so plans. However, candidates who plan only a year of research after obtaining the Bachelor Degree, or who plan to read for a Master's Degree, will not be excluded from these fellowship grant. Each Fellowship is worth approximately $4,000.

GERBER BABY FOODS SCHOLARSHIPS. Six undergraduate Scholarships at $1000 each, per year, intended to cover the last two school years leading to a Bachelor's degree in Food Technology, Food Engineering, or Food Science.

(Continued from page 64)

will be responsible for the development and coördination of personnel and industrial relations in all the company's various plants and branches.

Glenn H. Freeman has been appointed sales manager of Adolph's Industrial Food Products Co. Mr. Freeman, an IFT member, joined Adolph's after 18 years with Huron Milling Co., for which he most recently was director of sales.

Glenn H. Freeman

Arthur S. LaPine & Co. has announced the opening of a new showroom, where laboratory equipment will be on display, at 4705 Miller Ave., Bethesda, Md. **H. C. Smith** is manager of the new office and showroom.

. . . building up and branching out

Kelco Co., world's largest producer of algin products for thickening, emulsifying, gel producing and similar uses, has begun construction of this $250,000 research laboratory in San Diego. The laboratory will provide for advanced technical service to Kelco industrial customers, research in the chemistry of algin and investigation of new market developments.

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EMPLOYMENT NOTICES

AVAILABLE: After September 1, Ph.D. with a Dairy and Food Technology major, bacteriology minor, and an excellent background in chemistry. Military service completed. Desire position in new product development or quality control. REPLY BOX 539, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: CHEMICAL SALESMAN for Mid-west area to call on food and pharmaceutical manufacturers. Some technical and sales background preferred. Salary and expenses. REPLY BOX 540, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Food Technologist and Bacteriologist B.S.—7 years experience in Product Development, Research and Control. Desires to relocate in South or Southwest. REPLY BOX 538, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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